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DEVELOPMENT OF A DUST CLOUD MASS MEASURING SYSTEM

Kaman Sciences Corporation
P.O. Box 7463
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1 January 1979

Final Report for Period 1 June 1978—31 December 1978

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This report describes the concepts, design feasibility, fabrication and testing of a dust cloud mass measuring system. The early-time (<2 minutes) measuring system featured an aerodynamically designed measuring canister and a helicopter delivery and sighting technique specifically designed for use on MISERS BLUFF Phase II, Events 1 and 2. The report describes the development activities and field testing. Due to operational (not technical) problems, no dust measurements were made in either of the MISERS BLUFF events. Conclusions,

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20. ABSTRACT (Continued)

recommendations and a detailed drawing package of the measuring canister are also presented.

SUMMARY

With the consideration of multiple aim point basing for weapon systems such as the Air Force MX System, an increasing amount of interest has been shown in the measurement of multiple burst dust cloud properties (e.g. mass and particle distributions). In March of 1978, an intensive program was begun to develop a system to sample clouds generated in the MISERS BLUFF, Phase II, events. The program consisted of three phases including 1) concept and design feasibility, 2) air-drop system development, and 3) participation on MISERS BLUFF, Phase II, Events 1 and 2.

After comprehensive sensor trade-off studies, a light-weight aerodynamically designed canister was selected for futher development. This canister featured light-weight aluminum construction, a cyclone dust separator, an active capacitive measurement of the accumulated dust mass which was recorded via an on-board recorder, explosive guillotine actuated closures for protection of the collected sample and a 1.8 meter (6 foot) diameter deceleration parachute for impact survival. The delivery system selected was a helicopter with racks to hold up to six measuring canisters and a simple gravity-seeking targeting device.

As a result of a combination of aerodynamic design problems, sighting inaccuracies and concern about possible impact voiced by agencies with experiments near the detonation site, participation was cancelled on Event 1. After corrective action on the design deficiencies, a simulated dust ingestion field test on 30 July 1978 showed the system to be entirely functional and ready for the Event 2 test. A number of practice drops at the Nevada Test Site also demonstrated an acceptable sighting accuracy.

During Event 2, a countdown delay at 15 minutes prior to detonation required all airborne aircraft to return to their base of operations. When the countdown was resumed, the canister carrying the helicopter was not able to re-establish the delivery sequence in the remaining time and was north of ground zero at detonation time. Although the six measuring canisters were dropped in hopes of penetrating the northern edge of the dust cloud, no measurements were obtained.

Although not successful in the MISERS BLUFF test, laboratory and field testing had shown that the mass measuring canister would actively measure and passively collect accumulated dust as it traversed an early-time dust cloud. The delivery system was unique and functional and had also been demonstrated in many field tests. Except for the measurements during MISERS BLUFF Phase II, Events 1 and 2, all the design goals of the program had been met.

The following are recommendations for system refinements:

- additional active measurement capability.
- softer passive collection techniques with less abrasion and less impact to better preserve sample integrity.
- eliminate the deceleration parachute and design for a high velocity impact.
- electronic tracking and release point identification.
- examination of other delivery methods for a smaller designed canister.
- design of a positive positioning system to assure delivery over ground zero at a predetermined time.

- refinement of the communication system with the airborne delivery platform.
- refinement of the lanyard system used for initiation of functions starting at release from the helicopter.

These recommendations are discussed in detail in Section 5.

PREFACE

This is the final report for Contract DNA 001-78-C-0207 describing the design, development, and testing of a dust cloud mass measuring system at Kaman Sciences Corporation (KSC). This work was sponsored by the Defense Nuclear Agency (DNA) under RDT&E RMSS Code B3420 28462 H35HAXYX956-02 and 04 H2590D. The activities described in this report were conducted from March of 1978 through August 1978, which was the detonation of MISERS BLUFF, Phase II, Event 2.

This program was administered by Captain A. T. Hopkins. Program Management at KSC was under the direction of Tom Meagher with Richard Duke, the Project Manager. Other members of the scientific team were Victor Allen, Doug Elder, Frank Hassey, Fred Kimbley, Neil Koozer, Moe Morris, and Ted Tetman.

Conversion factors for U.S. customary
to metric (SI) units of measurement.

To Convert From	To	Multiply By
angstrom	meters (m)	1.000 000 X E -10
atmosphere (normal)	kilo pascal (kPa)	1.013 25 X E +2
bar	kilo pascal (kPa)	1.000 000 X E +2
barn	meter^2 (m^2)	1.000 000 X E -28
British thermal unit (thermochemical)	joule (J)	1.054 350 X E +3
calorie (thermochemical)	joule (J)	4.184 000
cal (thermochemical)/cm^2	mega joule/m^2 (MJ/m^2)	4.184 000 X E -2
curie	*giga becquerel (GBq)	3.700 000 X E +1
degree (angle)	radian (rad)	1.745 329 X E -2
degree Fahrenheit	degree kelvin (K)	$t_K = (t°f + 459.67)/1.8$
electron volt	joule (J)	1.602 19 X E -19
erg	joule (J)	1.000 000 X E -7
erg/second	watt (W)	1.000 000 X E -7
foot	meter (m)	3.048 000 X E -1
foot-pound-force	joule (J)	1.355 818
gallon (U.S. liquid)	meter^3 (m^3)	3.785 412 X E -3
inch	meter (m)	2.540 000 X E -2
jerk	joule (J)	1.000 000 X E +9
joule/kilogram (J/kg) (radiation dose absorbed)	Gray (Gy)	1.000 000
kilotons	terajoules	4.183
kip (1000 lbf)	newton (N)	4.448 222 X E +3
kip/inch^2 (ksi)	kilo pascal (kPa)	6.894 757 X E +3
ktap	newton-second/m^2 (N-s/m^2)	1.000 000 X E +2
micron	meter (m)	1.000 000 X E -6
mil	meter (m)	2.540 000 X E -5
mile (international)	meter (m)	1.609 344 X E +3
ounce	kilogram (kg)	2.834 952 X E -2
pound-force (lbs avoirdupois)	newton (N)	4.448 222
pound-force inch	newton-meter (N·m)	1.129 848 X E -1
pound-force/inch	newton/meter (N/m)	1.751 268 X E +2
pound-force/foot^2	kilo pascal (kPa)	4.788 026 X E -2
pound-force/inch^2 (psi)	kilo pascal (kPa)	6.894 757
pound-mass (lbm avoirdupois)	kilogram (kg)	4.535 924 X E -1
pound-mass-foot^2 (moment of inertia)	kilogram-meter^2 (kg·m^2)	4.214 011 X E -2
pound-mass/foot^3	kilogram/meter^3 (kg/m^3)	1.601 846 X E +1
rad (radiation dose absorbed)	**Gray (Gy)	1.000 000 X E -2
roentgen	coulomb/kilogram (C/kg)	2.579 760 X E -4
shake	second (s)	1.000 000 X E -
slug	kilogram (kg)	1.459 390 X E +1
torr (mm Hg, 0° C)	kilo pascal (kPa)	1.333 22 X E -1

*The becquerel (Bq) is the SI unit of radioactivity; 1 Bq = 1 event/s.
**The Gray (Gy) is the SI unit of absorbed radiation.

A more complete listing of conversions may be found in "Metric Practice Guide E 380-74," American Society for Testing and Materials.

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SECTION 1
INTRODUCTION

This final report describes the program for the development of a dust cloud mass measuring system. Such a system was designed to actively measure the particle size and apparent spatial density as well as collect a sample of dust lofted into the air by a surface detonation of high explosive. The delivery system was developed to permit several canisters to accurately measure an early-time (< 2 minute) dust cloud.

To meet the objectives of the program, it was decided that such a measuring system should be a moving system. The measuring device would traverse the cloud at high velocity and early-time to collect and measure the dust sample. Active measurements of the accumulated dust sample would be recorded on an on-board tape recorder for recovery after impact. Several measuring techniques were considered in the measuring canister to increase the data reliability and time and spatial resolution. These included, for sample collection, 1) filter paper or cloth separation, 2) cyclone separation, and 3) compartment or bins that could be varied with time. Techniques considered for active measurements included 1) acoustic impact, 2) capacitive impact, 3) inline capacitive, and 4) integrated capacitive. For the delivery systems, three methods were considered. These were 1) a howitzer or mortar propulson/aiming mechanism, 2) a fixed wing aircraft, and 3) a rotary wing (helicopter) delivery system.

Included in this report are the details of the program plan and measuring system design. The measuring system design discussion describes the concept feasibility, aerodynamic, mechanical, and electrical design as well as the development of the delivery system. The program conclusions and recommendations for system improvements are also included.

SECTION 2
PROGRAM PLAN

2.1 Program Outline

The program plan for the development of a dust cloud mass measuring system included three phases covering a period of six months starting in March of 1978. The three phases were 1) Engineering Feasibility Demonstration, 2) Air Drop System Development, and 3) Dust Cloud Measurements - MISERS BLUFF Event 2. Originally our participation was only planned on Event 1 (Phase I and II) which was to be detonated on 28 June 1978. Later, the program was ammended to include more development of the sighting and delivery system and participation on Event 2 which was on August 30, 1978. The detailed description of the tasks for each phase was as follows:

Phase I. Engineering Feasibility Demonstration

1. Sensing technique evaluation
2. Air-drop canister design

Phase II. Air-drop system development and Test

1. Delivery system evaluation
2. Sighting and Mounting Rack Design
3. System Field Testing
4. Participation on MISERS BLUFF, Phase II, Event 1

Phase III. Dust Cloud Measurements on MISERS BLUFF Event 2

1. Event 1 Performance and Data Evaluation
2. Event 2 Design Improvements
3. Fabrication and Fielding of Four or More Units for Event 2
4. Design and Test an Accurate Sighting Mechanism

5. Fabrication of Test Canisters for Accuracy Testing
6. Test Deployment and Sighting Mechanism Evaluation
7. Event 2 Performance and Data Evaluation
8. Final Report Preparation

Although the original program plan called for our participation on Event 1 of MISERS BLUFF, several problems, including aerodynamic design, sighting accuracy and concern of other experimenters about possible damage from canister impact led to the cancellation of our participation on June 23, 1978.

On Event 2, a 15 minute hold prior to the detonation time made it necessary for the helicopter to return to the landing strip. When the countdown was resumed, there was not sufficient time for the helicopter to regain altitude and position prior to the detonation. Although the helicopter crew tried to obtain a substitute position at the northern edge of the dust cloud, the drop of the six measuring canisters failed to penetrate the edge of the dust cloud; hence, no measurements were obtained. The canisters had to be dropped by T + 2 minutes to avoid compromising the prime cloud-sampling aircraft experiments.

SECTION 3
MEASURING SYSTEM DESIGN

3.1 Feasibility Study

As noted in the Introduction, several options existed concerning measuring technique, housing design, and delivery system. Also the realistic restrictions of time were to be considered with the first event only four months away from the start of the program.

The arbitrary decision to make the measuring device a moving system with on-board recording and multiple measurements was the starting point of the study. Since the problems of dust cloud particle sensing and collection most often can be combined, the following options appeared most reasonable:

1. Acoustic and capacitive impact (front)/inline capacitive flow-through/filter bag or paper separation.

2. Acoustic and capacitive impact (front)/cyclone separation/integrated capacitive collection.

3. Same as (2) except the use of bins or compartments could increment the collection with time.

The advantages and disadvantages of each of the foregoing systems are presented in Table 1. After some laboratory testing, analytical study, review of current literature and consultation with specialists, a simple system consisting of cyclone separation with integrated capacitance collection was chosen. Selection of this system was influenced by the limited development time

Table 1. Measurement and Collection System Comparisons

Measurement or Collection System	Advantages	Disadvantages
Acoustic Impact	Actively measure particle density (number and frequency of impacts) altitude (impulse time.) Most of the basic technology exists for development.	Response to dynamic range of particle size beyond state-of-art in electronics Collection and storage of impact data requires development of sophisticated digital electronics for small on-board digital recorder.
Capacitive Impact	Actively measures particle density (number and frequency of impacts) and size (magnitude of impact)	Laboratory data indicated that with present technology, no system could be designed to sense particle sizes over the anticipated centimeter to micron range. Extensive development required.
Capacitive in-line	Actively measures particle density (amount passing through capacitance sensors).	Difficult to directly measure particle size. Has same disadvantages as capacitive impact.
Integrated Capacitive	Actively measures particle density (amount accumulated with time). With tapered collection chamber, sensitivity can be varied with apparent sample size.	Does not actively measure particle size.
Collecting Bins	Used with integrated system, bins can be varied with time and separate sample into various altitude regions. From this an average density and particle size can be expressed for the various regions.	Compartment vs. time mechanism needs to be developed.
Filter Paper or Cloth	Passive collects sample. Could be designed for low impact speed collection to protect particle size.	Could be torn or ripped by high velocity particle.
Cyclone Separator	Commercially available in small sizes. Works well with integrated capacitance measuring system.	Particles are impacted on several surfaces during collection. Larger particles most likely broken into smaller sizes.

before Event 1, however, it was hoped that continued activities leading up to Event 2 would expand our measuring technique capability.

For the delivery system, fixed-wing aircraft, helicopter and powder guns (either mortar or howitzer) were considered. For both the fixed-wing aircraft and powder gun delivery systems, the delivery accuracy depends greatly on a thorough knowledge of the actual aerodynamic performance of the measuring canister. Because of the lack of time to characterize this performance, the only reasonable delivery system choice appeared to be the helicopter system. For a helicopter, the canisters could be dropped from a hover or near-hover position directly above the target.

3.2 Aerodynamic Design

The objectives of the aerodynamic design were that the canister:

1. would have a six inch diameter inlet sampling area to minimize weight as determined by payload characteristics of the helicopter

2. would weigh approximately (178 newtons) 40 pounds to minimize weight as determined by payload characteristics of the helicopter

3. would have a terminal velocity of 106.68 m/sec (350 ft/sec) which it would obtain in the first 1067 meters (3500 feet) of decent

4. would have minimal internal drag associated with the particle collection system

5. would have a low drag exterior surface

6. would have excess aerodynamic stability

7. would have a maximum body diameter of one foot

After careful design analysis and a test drop at Fort Carson, it was decided that a flow-through canister could be designed to meet these goals. The basic design approach was a sleek, thin-walled, reinforced aluminum structure with special rear stabilizing fins and a combined drag coefficient of between 0.2 and 0.4 (based on frontal area). The stabilizing fins were releasable and when released from their mountings, were used to pull the impact deceleration parachute from its housing. A photograph of this design showing some of the external features is shown in Figure 1.

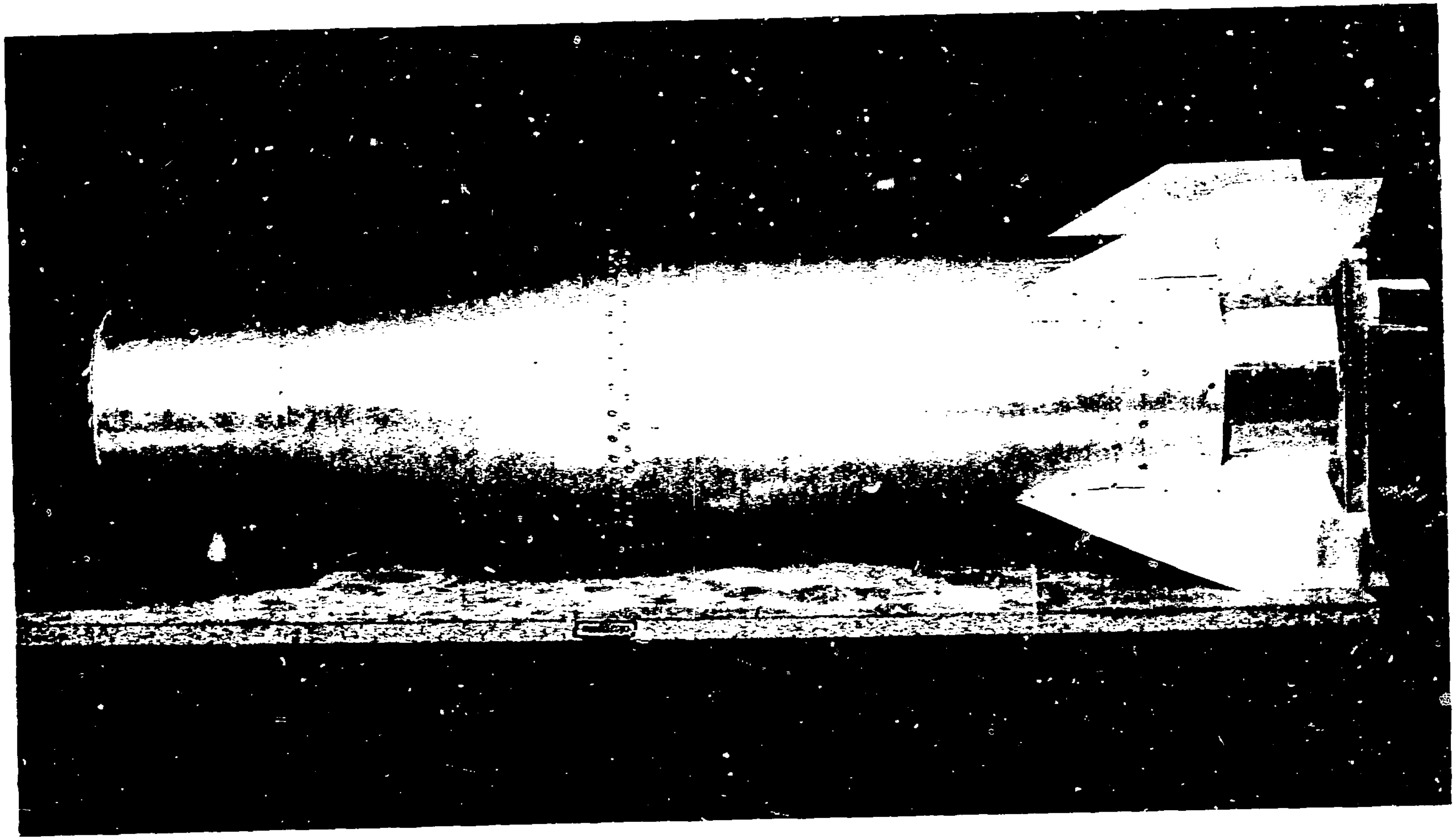
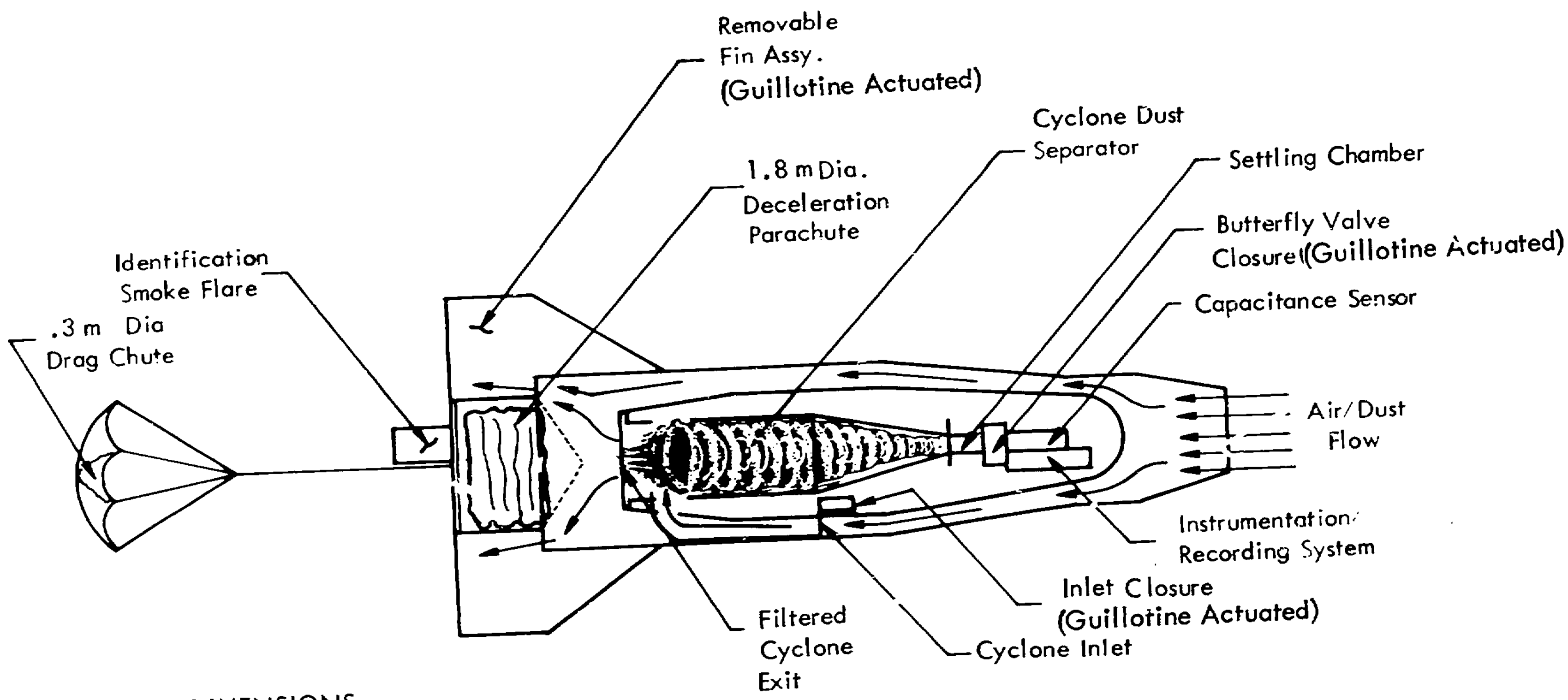


Figure 1. Photograph of Dust Measuring Canister

When the first test units were fabricated, the final location of the center of gravity was considerably aft of the desired location. The unit weight of the canister was also slightly high at 215 newtons (48 pounds). A test drop made in mid June, indicated that the test unit was not statically stable.

A careful examination of both the static and dynamic stability of the canister was made. It was agreed to add (90 newtons) 20 pounds of ballast in the nose and to axially balance the canister statically to eliminate possible dynamic instabilities. In subsequent tests, no aerodynamic instabilities were noted; however, the deployment scheme for the deceleration parachute failed to work. Excessive negative base area pressure was determined to be the cause of the problem and a drag chute was added to the fin assembly. The drag chute aided the design in two ways by providing a positive loading for the fin removal at the proper time and by reducing the higher terminal velocity, caused by the added weight, from over 122 meters per second (400 feet per second) to approximately 79 meters per second (260 feet per second). Both of these factors improve the probability of survival on impact. Details of the final design are shown in Figure 2.



CANISTER DIMENSIONS

Length	1.4 m (54.2 in)
Max. Dia.	.6 m (24 in) at Fin Tips
Body Dia.	.3 m (12 in)
Inlet Dia.	.15 m (6 in)
Weight	289 newtons (65 lbs)

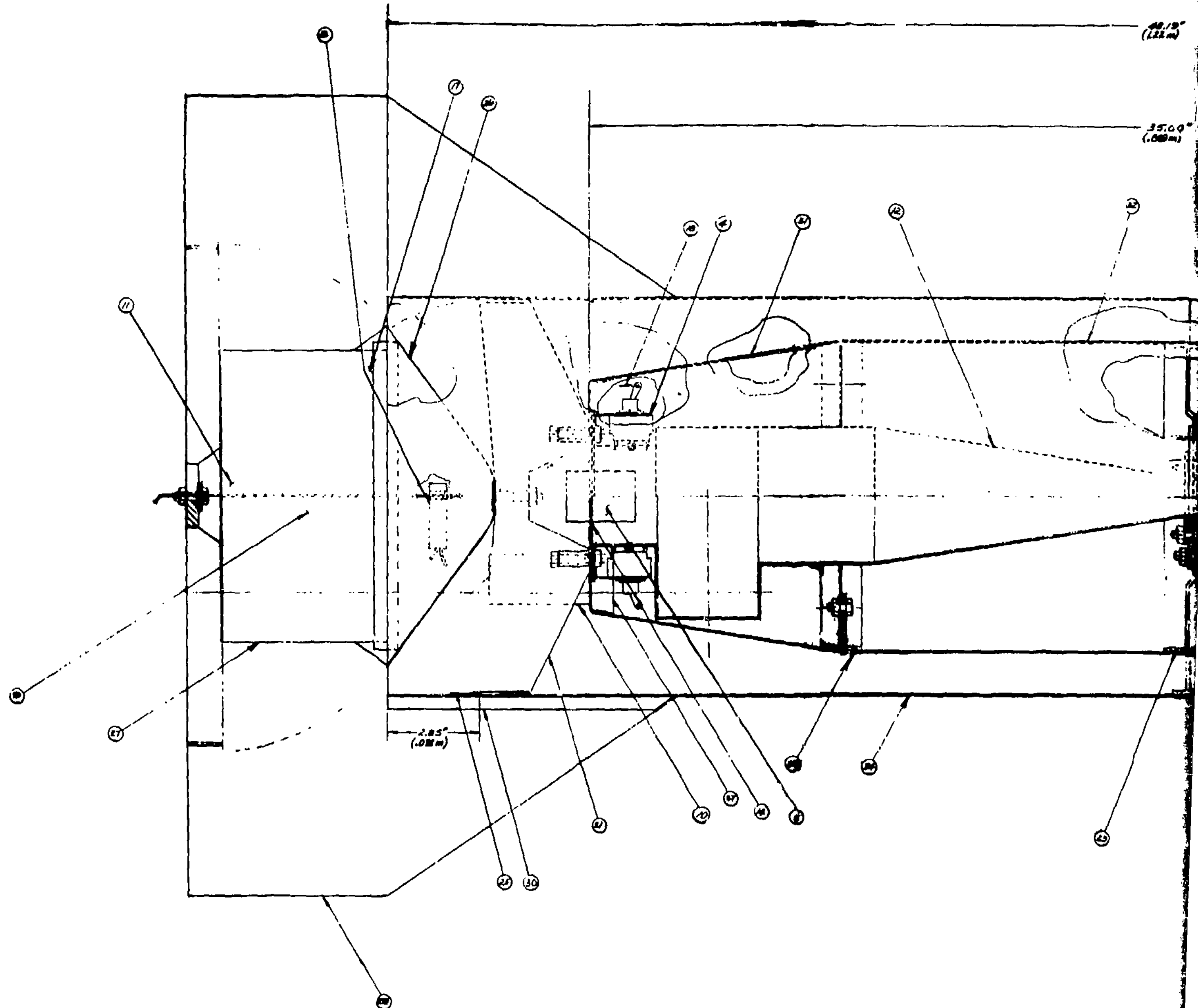
Figure 2. Canister Dust Measuring System

3.3 Mechanical Design

In addition to the noted objectives of the aerodynamic design, the mechanical design added the requirements of 1) impact survivability, 2) sample collection and protection, 3) general mechanical design for aerodynamic configuration, and 4) housing of the various components. In Figure 3, the details of the mechanical design are shown. Detailed drawings of the various parts to the assembly are presented in Appendix A.

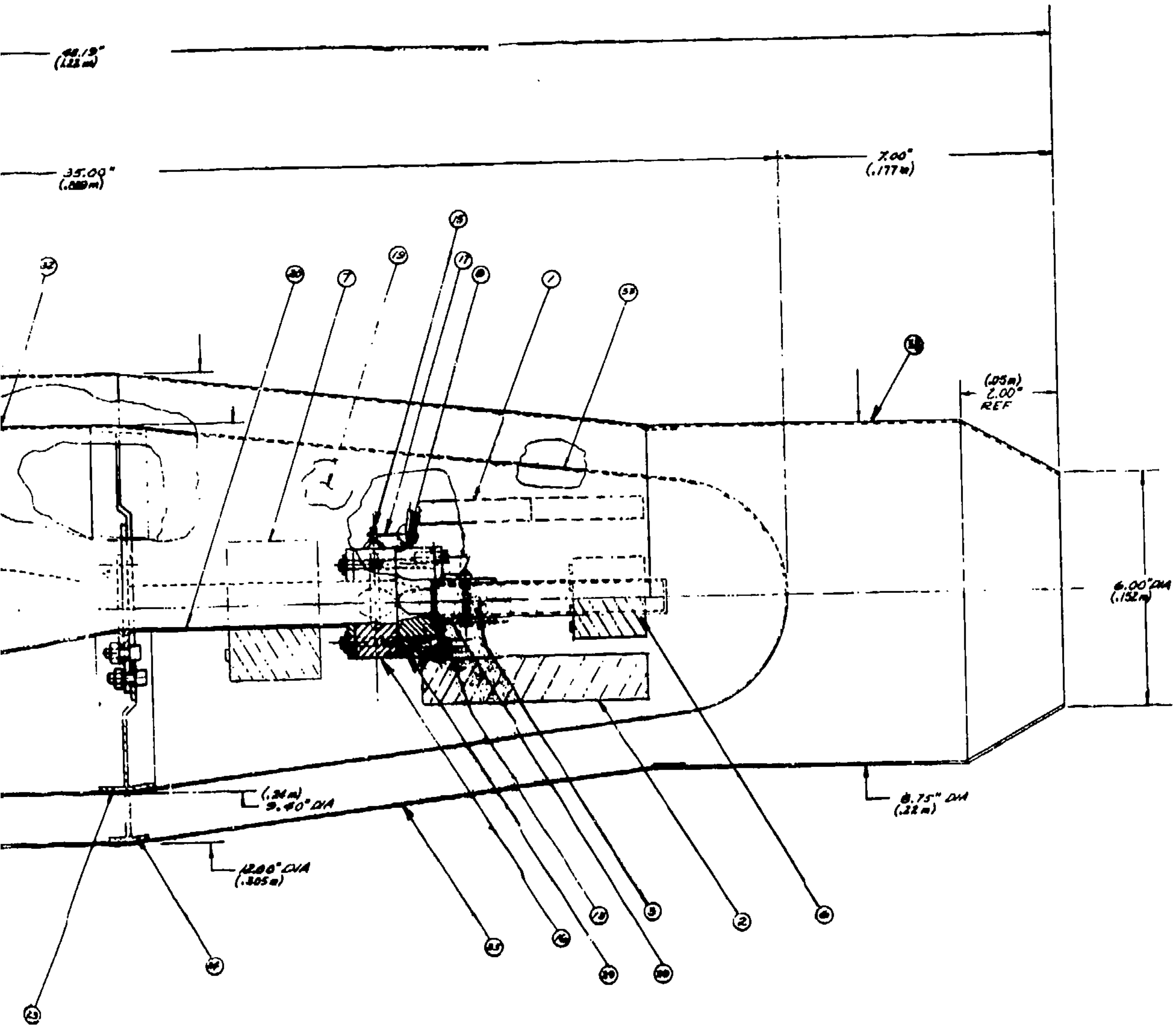
Again, the basic approach to making the model was to use a thin wall riveted aluminum assembly mounted to a 4130 aircraft steel "stong-back" rear bulkhead. both the outer skin, inner pod and fin assembly would be attached to this bulkhead. During impact, the outer skin would buckle and crush thus absorbing and disapating the impact energy and the inner pod containing the cyclone separator and the active instrumentation would survive undamaged.

Other features of the design noted in Figure 3 are the cyclone, the cyclone closure, the cyclone separator, the settling chamber, the closure valve, the flow outlet final filter, the parachute compartment, the stabilizing fins and the smoke flare. In principle, the cyclone is designed around the fact that the particles cannot follow the path of the air stream and are thrown to the outer walls. For the anticipated flow rates of this design, this fact was supposedly true for particles as small as 10 microns in size. These particles then settle into a chamber where they can be collected and measured. The filter on the outlet assures that re-entrained particles can not escape the chamber. The two closures (one at the cyclone entrance and one in the settling chamber) assure total protection for the sample of the collected dust for later evaluation. The closures are both spring-loaded and guillotine-actuated. The



Key to Design Features

1	Signal Cond. Electronics	17	Trigger Wire	33	Nose Skin
2	Tape Recorder	20	Settling Chamber	34	Aft Shroud
3	Sensor Assembly	21	Aft Rib	35	Mid Shroud
4	On-off Switch	22	Mid Rib	37	Cyclone Mtg. Flange
5	Time-delay Relay	23	Forward Rib	38	Inlet Shroud
6	Power Supply	24	Spacer		
7	Power Supply	26	Flexible Closure		
8	Guillotines	27	Parachute		
9	Parachute	28	Fin Assembly		
12	XQ-3 Cyclone	30	Fin Guides		
14	Final Filter	31	Aft Skin		
16	Closure Assembly	32	Mid Skin		



d
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tg. Flange
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FIGURE 3 CANISTER DESIGN

explosively driven guillotine is initiated by an electrical signal from the control electronics. This same type guillotine is used to release the parachute prior to impact.

The fin assembly is primarily for aerodynamic stability but also is used in a parachute removal scheme. A small drag chute was used to overcome a negative base pressure on the fin assembly. The fins were held in position by angle-bracket tracks on the canister body and secured by a steel cable. When the canister approached within 151 to 303 meters (500 to 1000 feet) of impact, the guillotine severed the cable, and the fins and drag chute pulled out the deceleration parachute. The smoke flare attached to the aft end of the fin assembly was used to enhance visual and photographic identification during its flight.

To test the operational aspects of the canister, several tests were performed. The tests included laboratory, vehicle-mounted and helicopter-deployed. Proper functioning of all aspects of the canister operations were verified in these tests. The culmination of such testing came at Butte, Montana on 30 July 1978, where an actual dust measuring canister was dropped. The canister was dropped from 2120 meters (7000 feet) above ground and contained a "tear-apart" tissue bag of dust in the flow inlet. In the test, all aspects of the measuring canister operated properly; i.e., the electronics turned on, dust was collected and measured, the electronics turned off, the guillotines operated at the correct time for dust sample closure and parachute release, the parachute deployed successfully and the canister survived impact with very little damage. Final preparations for Event 2 testing in late August were begun with "targeting" accuracy the only operational issue remaining. This aspect of the program is discussed in Section 3.5, Delivery System.

3.4 Electronics Design

The electrical block diagram for the measuring canister is shown in Figure 4. The objectives of this subsystem were to measure the accumulated dust versus time and to provide control signals for other functions including closures and parachute deployment. The measurement task was a most difficult one since predictions of dust cloud densities showed a dynamic range of approximately 10^4 in mass. Since this type of dynamic range is beyond the state-of-the art for most electronic systems, a tapered collection chamber was devised. The tapered collection chamber, filling from the apex, provides a linearizing effect, i.e., a little initial volume provides the same capacitance change as a larger delta volume added onto an existing volume of dust. The use of the tapered collection chamber reduces the required dynamic range of the electronic system down to approximately 10^2, well within the current state-of-the-art, permitting good comparitive assessment of the total accumulated mass. A total accumulated mass of 0.05 grams could be measured. The capacitance sensor was of the parallel plate type and was part of an A.C. bridge circuit. The rectified output of the circuit was fed to a voltage controlled oscillator. This frequency modulated signal was fed directly into a micro-cassette tape recorder (Pearlcorder Model S301) for recovery and playback later.

The timing electronics consisted of an electronically controlled time-delay relay. Time delays provided by the relay were adjustable from a few seconds to over two minutes. Selection of the proper time settings for functions were determined from practice drops of actual canisters in the field. A typical sequence of events for the canister electronics is as follows:

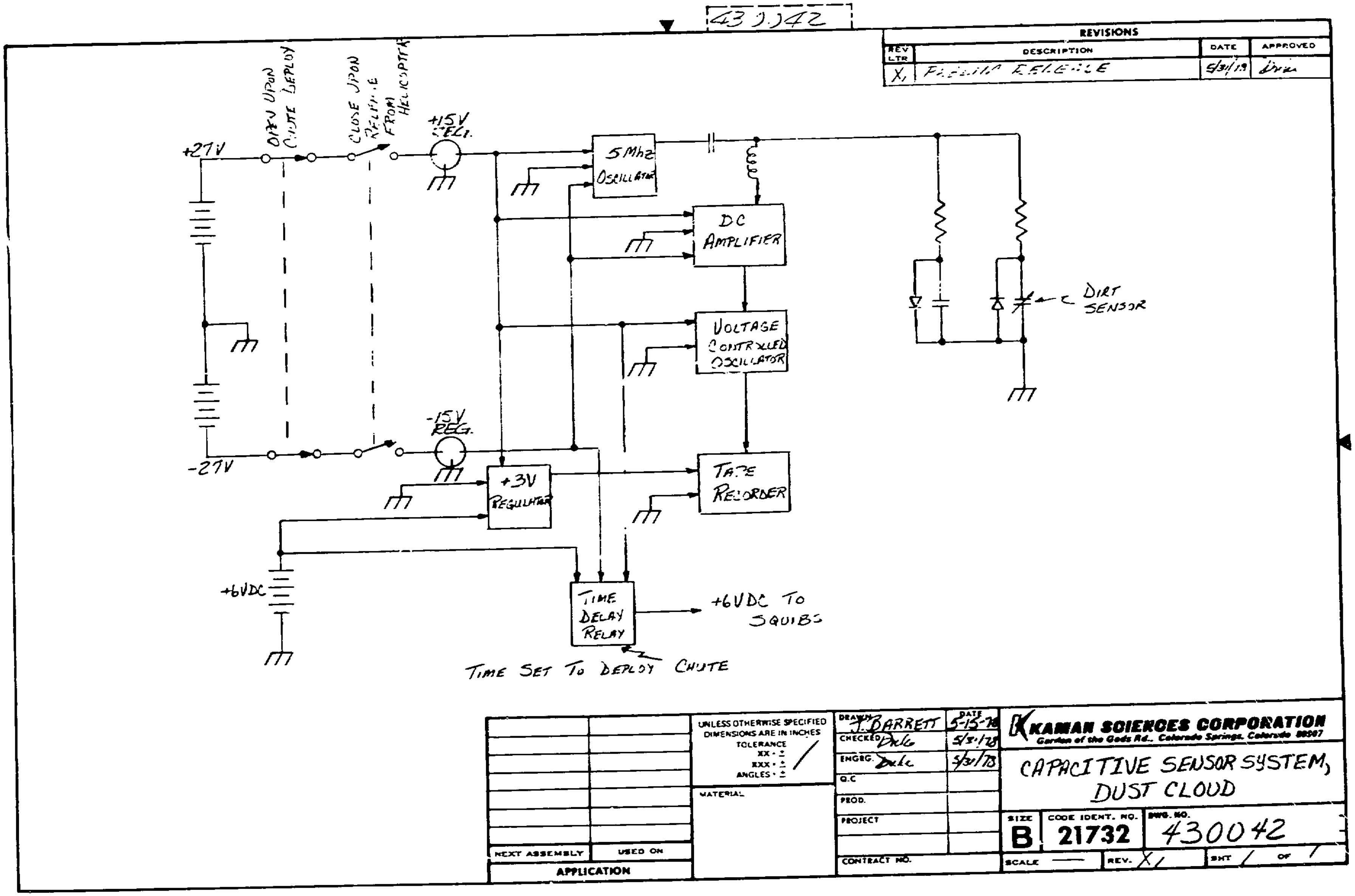


Figure 4. Electrical Block Diagram

Time zero - Turn on electronics (helicopter lanyard). Capacitance sensor ready for measurements.

Time t - At a set time interval (approximately 30 seconds for the MISERS BLUFF events), three explosive guillotines are fired. These release the parachute, close the inlet to the cyclone separator and close the collection chamber. The release of the parachute opens a switch that turns off all power to the electronics and tape recorder.

3.5 Delivery System Design

The goals of the delivery system were to design and implement a system for accurately dropping several measuring canisters through the dust cloud. The basic approach was to use a helicopter, with canisters mounted on the sides for release at the proper time. The principle details of the system are shown in Figure 5. Actual photographs of the delivery system are shown in Figures 6 and 7. In this scenario the helicopter would approach the drop area in a near hover and when properly stationed above the ground target as indicated via an optical sighting mechanism, the canisters would be released (see Figure 8).

Participation in MISERS BLUFF using a manned helicopter flying above the burst raised a question concerning safety. Specifically, it was necessary to choose a flight altitude such that the aircraft would not be subjected to an overpressure above the sure-safe level for that aircraft. In fact, realizing that the vehicle would be manned and that there were some uncertainties in predicting the blast field environment, it was reasonable

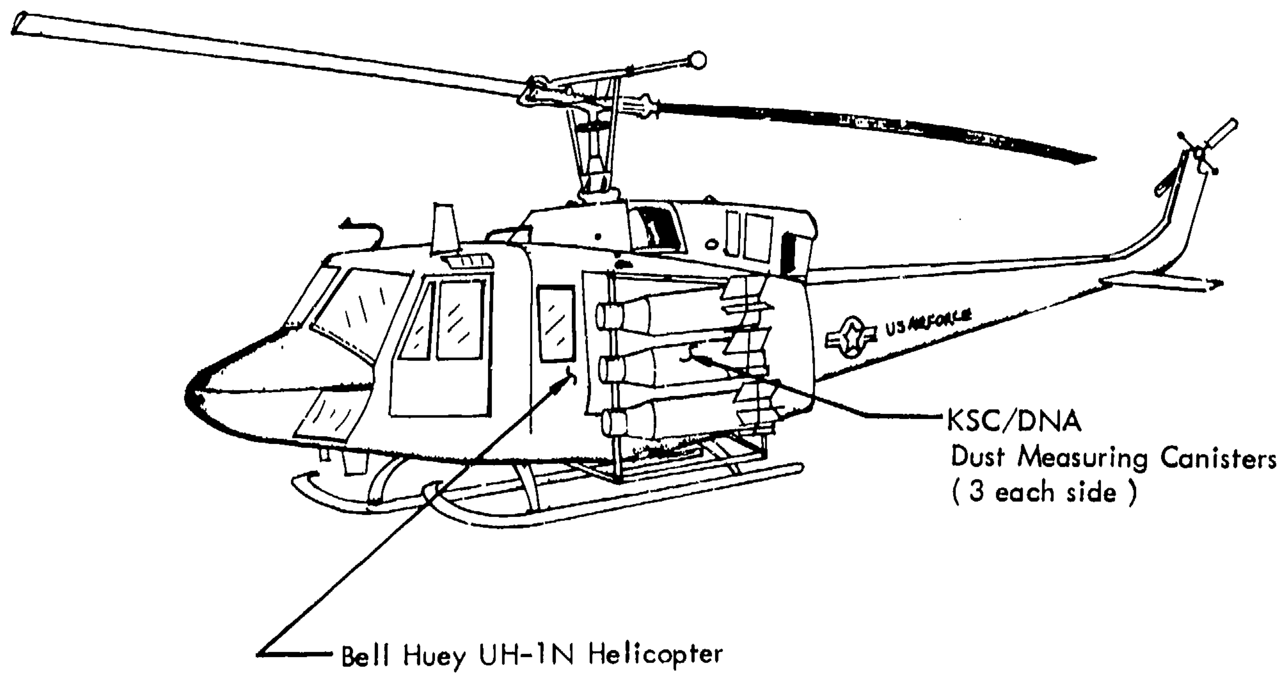


Figure 5. Helicopter Delivery System

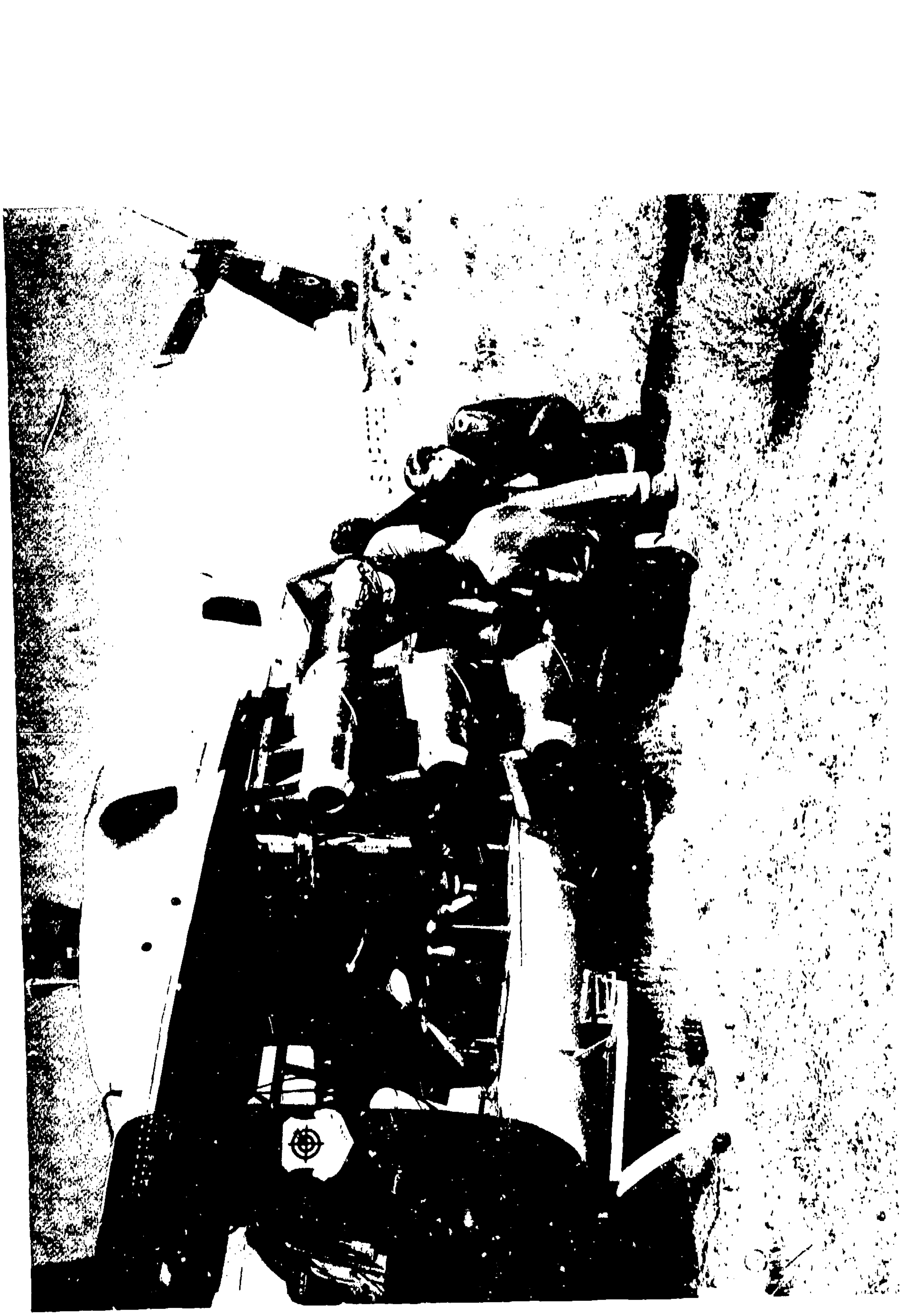


Figure 6. Loading of the canisters on the helicopter.

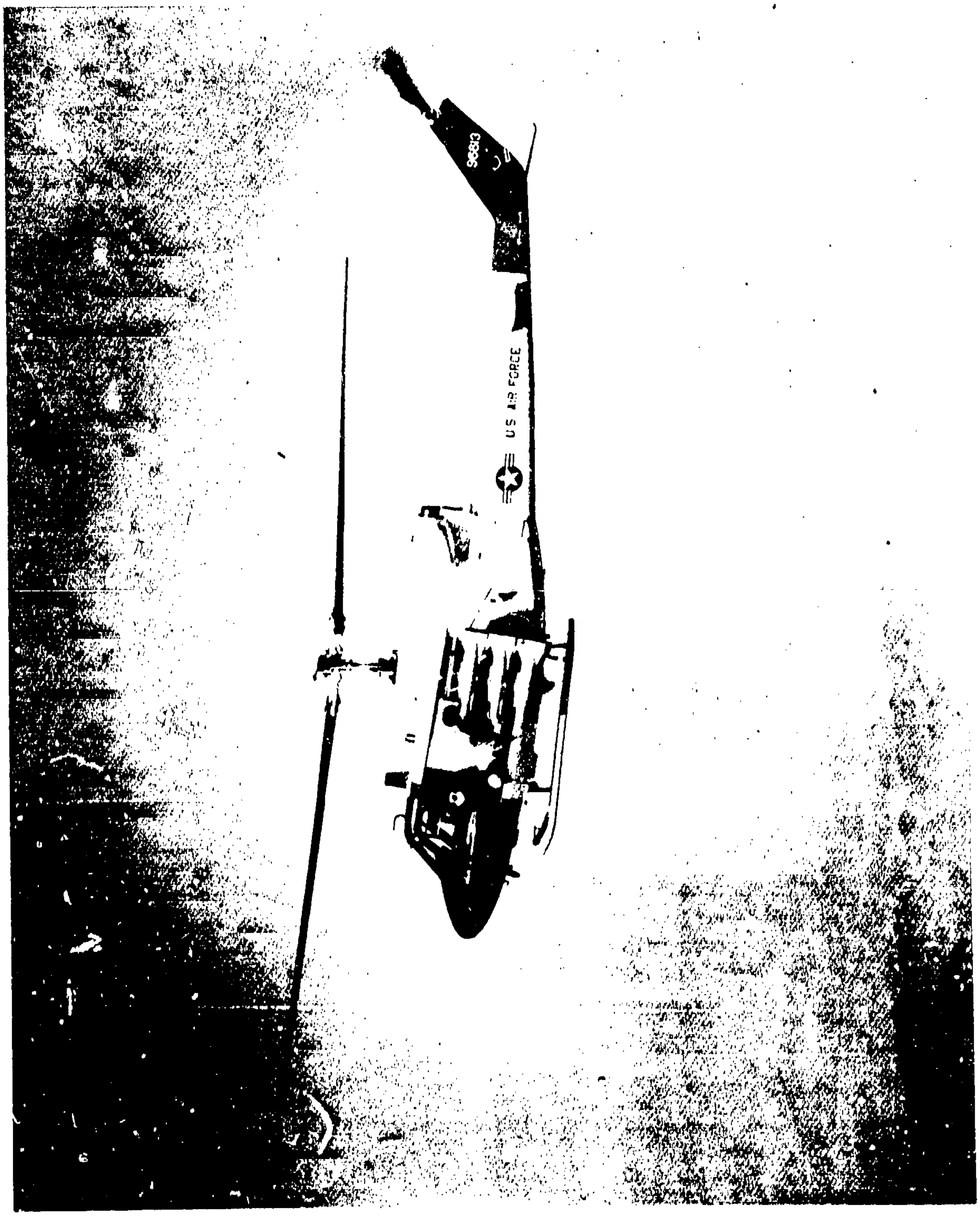


Figure 7. Loaded helicopter in flight.

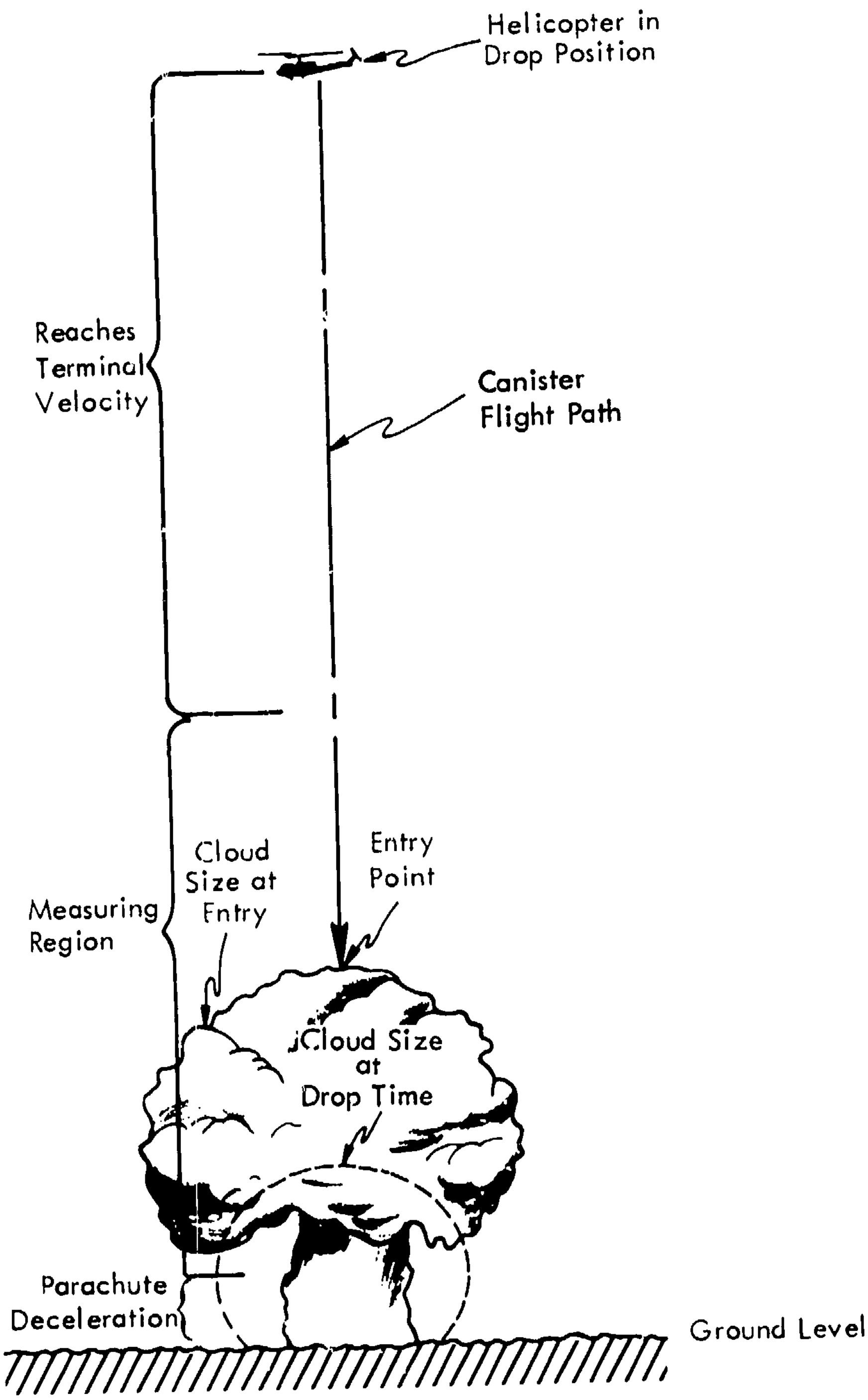


FIGURE 8. Dust Measuring Canister-System Diagram

to apply an additional safety factor of two beyond what was considered sure-safe to allow for blast overpressure prediction uncertainties.

Some data are available from tests conducted during the PRE-MINE, THROW-IV and DICE THROW Events. In these tests, a domed UH-1B helicopter received side-on blasts of 8963 Pa (1.3 psi) and 12411 Pa (1.8 psi) and the vehicle did sustain some damage, particularly at the higher level. It was concluded that for a blast directly on the side of a UH-1B, even the 8963 Pa (1.3 psi) level would be unacceptable. After some analysis and consultation with experts, it was estimated that for generic helicopters, the 1379 Pa (0.2 psi) overpressure level would provide adequate safety for all encounter conditions; including blasts from directly below (which load the main rotor blades).

For tests using large quantities of explosives, the 1379 Pa (0.2 psi) keep out zone requires the helicopter to fly at very high altitudes; e.g., the Event 2 mission was flown at 3936 meters (13,000 feet) above the blast site.

A detailed analysis of the response of a specific helicopter model in a simulated explosive burst is required if operations dictate closer positioning than about 1379 Pa (0.2 psi). Such a full analysis was not within the scope of KSC participation in MISERS BLUFF II Events and was not considered necessary because the predicted altitude corresponding to 1379 Pa (0.2 psi) was within the capability of the USAF helicopter employed. The KSC engineering judgement using safe-side environment and meteorlogical assumptions was documented in a memorandum from KSC Avidyne to KSC Science and Technology (see Appendix B).

Two additional problems with the delivery system selected were encountered. These were the problems of dropping the measuring canisters with the desired accuracy and the associated probability of impacting an experiment on the ground. The sighting mechanism evolved from simply a "seamans eye" through several mechanical devices of various degrees of sophistications. The final device selected consisted of a pendulum of clear lucite with crosshairs on the bottom and top. The pendulum was suspended in a clear, cylindrical container for elimination of wind loading and water filled to provide damping. The target point was indicated by aligning the upper and lower crosshairs. The sight indicated a path perpendicular to the drop surface. Through testing experience, it was found that inertial loads on the pendulum disk caused it to rock back and forth slightly. This motion, though small, had a significant effect on a target surface as great as 3936 meters (13,000) feet away, so a slow constant helicopter approach velocity was maintained to minimize this effect.

In the development stages, several test models and one actual canister were dropped as functional deployment and sighting experiments. The test models were of two types. The first was called a "free-fall dummy" and contained no electonics. It was the same size, shape, and weight as an actual canister, but was used only to measure total elapsed time from the helicopter to the ground. The second type was called a "chute dummy" since it contained all the necessary electronics and hardware for the deployment and testing of the deceleration parachute to permit observation of impact survival. Free-fall dummy decent times and estimates of terminal velocities were used to set the interval timers on the chute dummies. A summary of the drop testing is listed in Table 2.

TABLE 2

DROP HISTORY

DATE	TEST MODEL NUMBER	DROP LOCATION	DROP HEIGHT METERS (FEET)	DROP POSITION R (METERS/FEET)	DROP POSITION θ (degrees)*	Remarks**
15 June 78	Dummy 1	Meadow Lake Airport	2120 (7000)	908 (~3000)	155	Aerodynamically Unstable Used Sighting
17 July 78	Dummy 2	"	"	291(960)	297	"
"	Dummy Chute 3	"	"	303(1000)	55	"
20 July 78	Dummy Chute 4	"	"	73(240)	70	New Sighting Mechanism
"	Dummy Chute 5	"	"	218(720)	324	"
30 July 78	Dummy Chute 6	Butte, Montana	"	45(150)	330	"
	Dump 1	"	"	73(240)	0	"
25 Aug 78	Dummy 7	Area 14, NTS	2543(8400)	338(1115)	220	New Helicopter Crew
"	Dummy Chute 8	"	"	109(361)	180	"
"	Dummy Chute 9	"	"	358(1181)	300	"
"	Dummy Chute 10	"	"	~696(~2300)	120	"
"	Dummy Chute 11	"	"	99(328)	210	"
"	Dummy Chute 12	"	"	159(525)	135	"
27 Aug 78	Dummy 13	Bill Wms Ck, Ariz	3936(13000)	277(918)	330	

*Clockwise angular progression with 0^{o} at magnetic North

**Test models 1 thru Dump 1 were dropped using the Hiller-Saloy helicopter. All others were with the USAF UH-IN helicopter.

The problem of impact with other experiments was also studied by KSC for both Events 1 and 2. A circular error probability (CEP) was established using this liminted data base. A CEP of 200 meters was estimated from all test drop data. Using that accuracy and considering the testbed layout for Event 2 probabilities of impact of various experiments are shown in Figures 9 through 13. In these figures, the radial angle, distance and size of each experiment is noted and a probability of impact versus CEP is shown. As indicated, probabilities of one in a million or less were predicted for nearly all experiments on the ground.

For Event 1, a similar analysis was performed, but the analysis was further complicated by a larger number of experiments on the ground and the consideration of aim-point bias. The use of aim-point bias was considered to decrease the probability of impact for certain sensitive experiments.

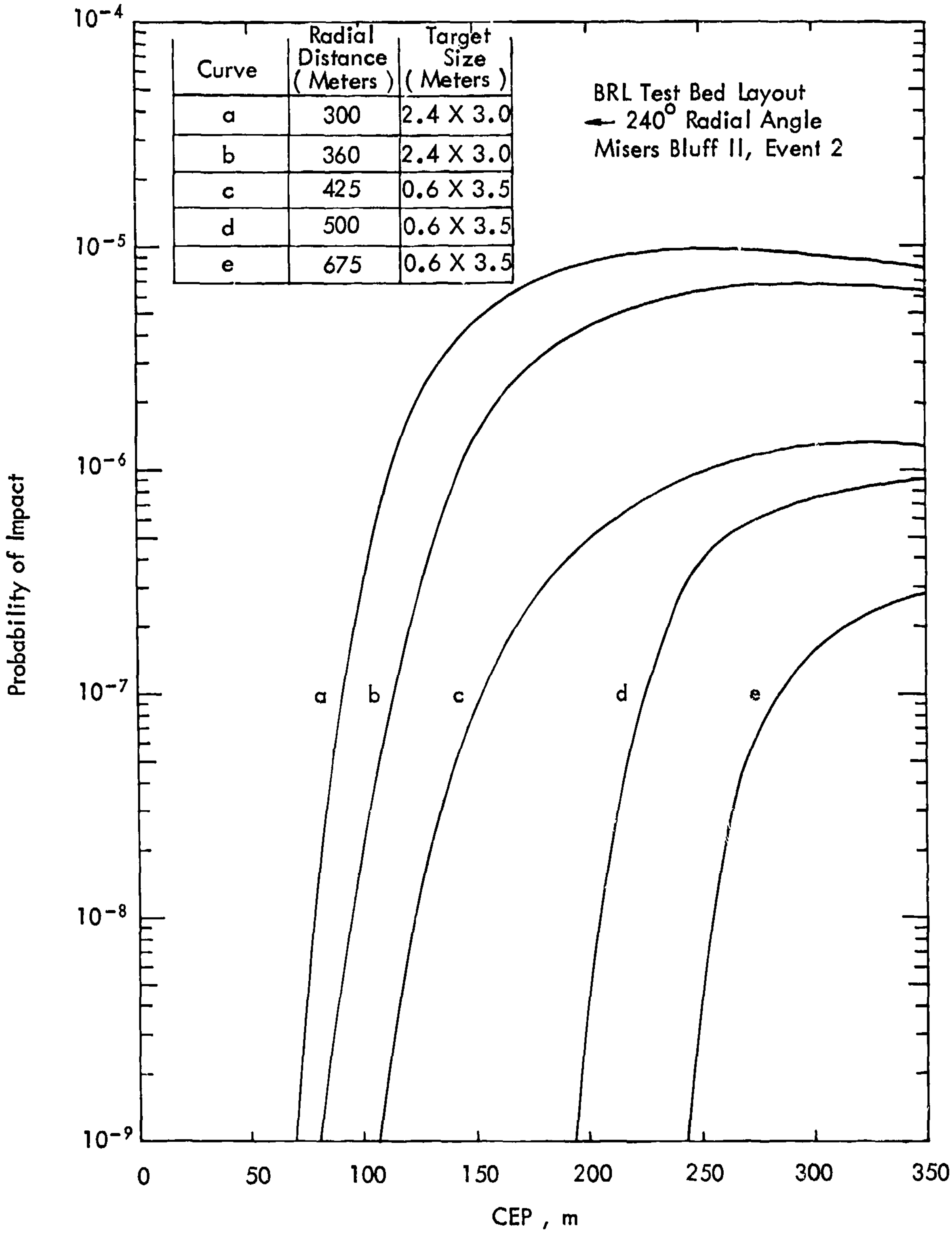


Figure 9. Probability of Impact Versus Canister CEP, BRL Experiments

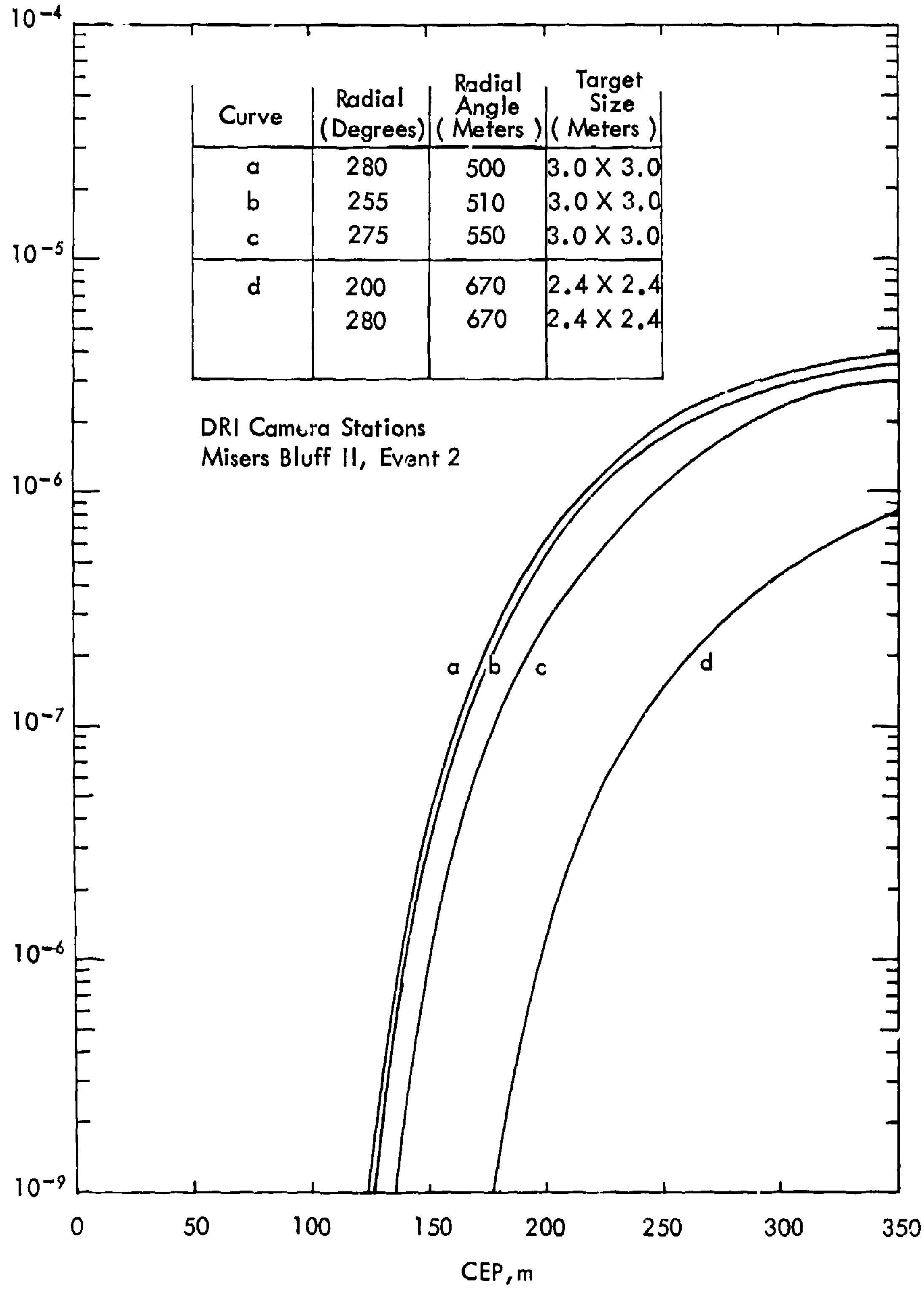


Figure 10. Probability of Impact Versus Canister CEP, DRI Camera Stations

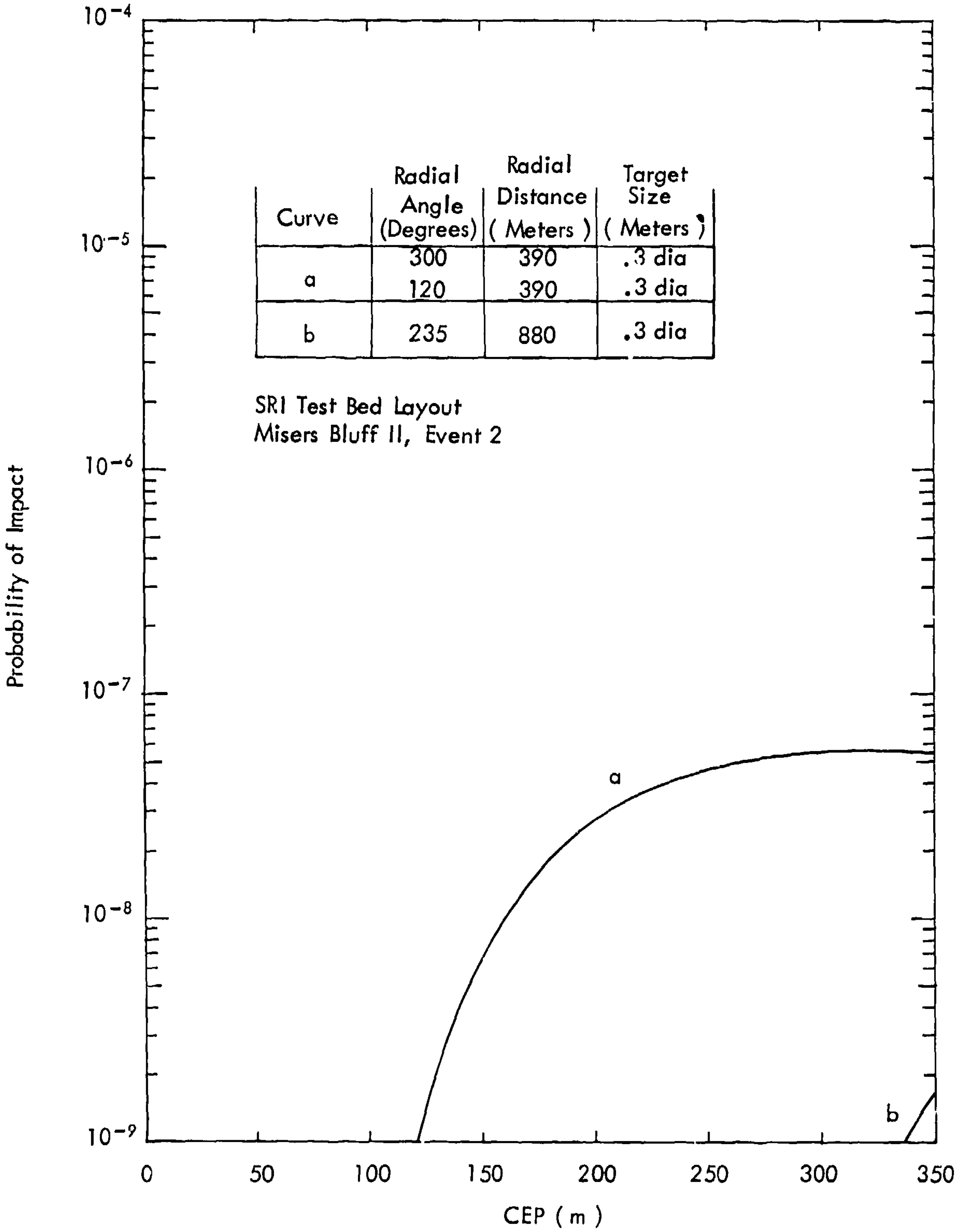


Figure 11. Probability of Impact Versus Canister CEP, SRI Experiments

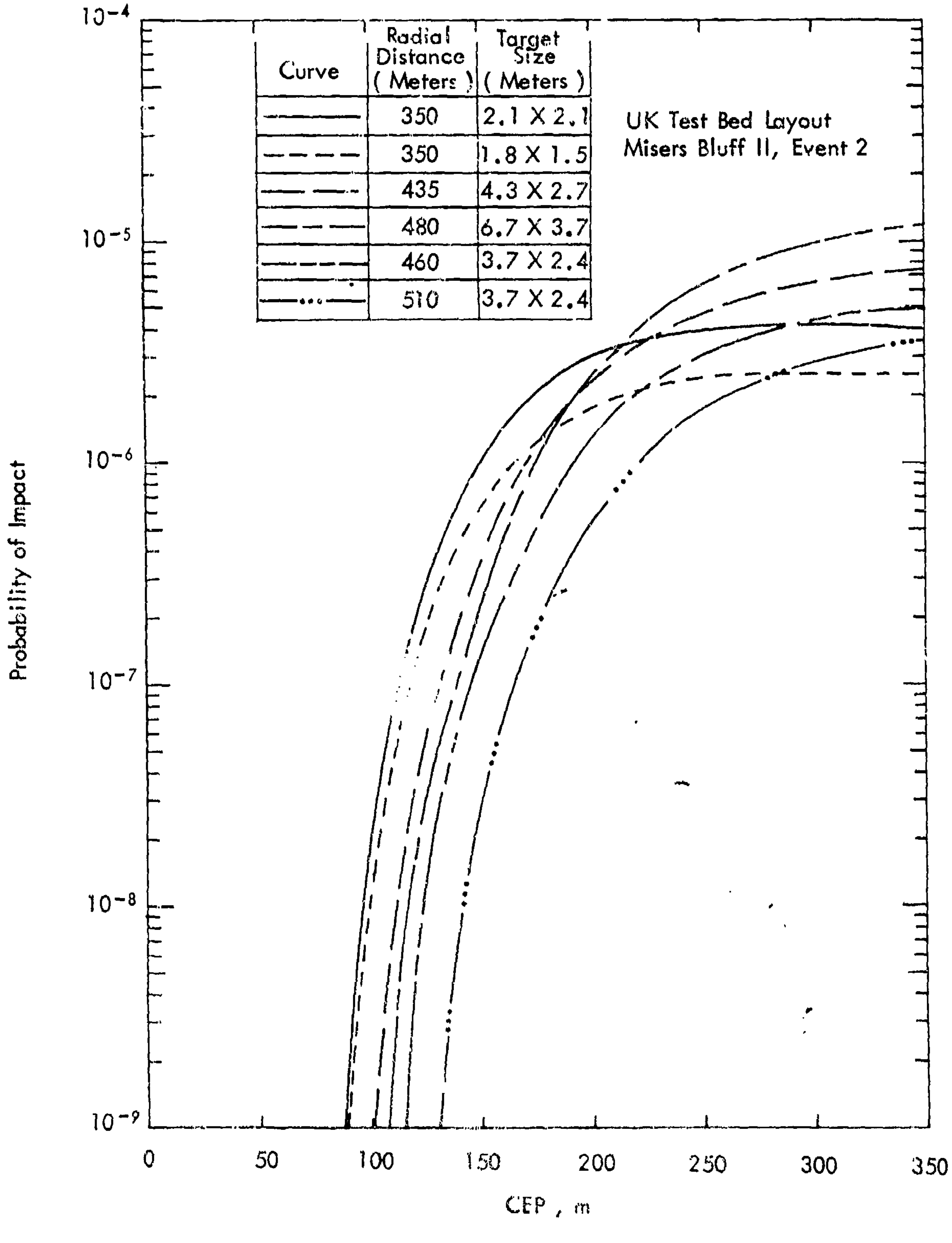


Figure 12. Probability of Impact Versus Canister CEP, UK Experiments

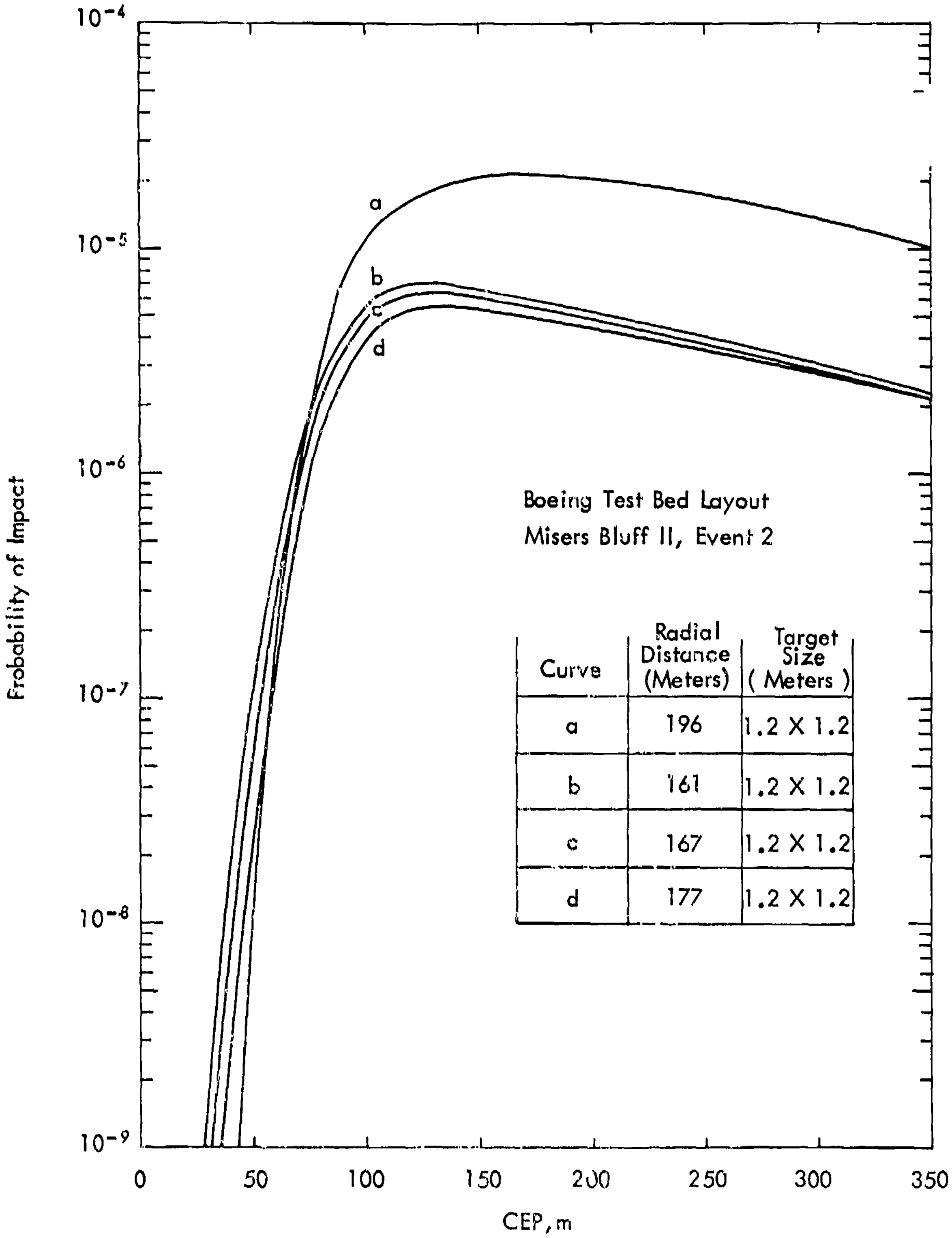


Figure 13. Probability of Impact Versus Canister CEP, Boeing Experiments

SECTION 4
CONCLUSIONS

In this intensive development program, virtually all the design goals of the program were met and many design firsts were achieved. A mass measuring canister was designed that actively measured and passively collected accumulated dust as it traversed a dust cloud. Also, a unique helicopter delivery system including portage and sighting mechanisms was designed, fabricated, and tested. This dust collector system made possible early time (< 2 minutes) dust cloud mass measurements.

No measurements were made in either Event 1 or Event 2 of the MISERS BLUFF II test series. Aerodynamic design problems and concern for ground impact accuracy led to the cancellation of Event 1. In Event 2, a countdown delay at 15 minutes prior to detonation required all airborne aircraft to return to their base of operations. When the countdown was resumed, the helicopter was not able to re-establish the delivery sequence in the remaining time and was north of the desired position when Event 2 was detonated. Six canisters were dropped in hopes of penetrating the northern edge of the dust cloud, but a field inspection of the units showed no dust had been collected. A real field demonstration of the canister measuring system was made in Butte, Montana on 30 July 1978, where dust that was held in the canister inlet by tissue paper was collected from the airstream, actively measured and protected during impact. This test clearly demonstrated the feasibility of both the delivery and measurement system.

Other notable successes of the program included the design and testing of the unique aerodynamic design, mechanical construction, electrical design, measurements schemes, and

delivery techniques. Each of these design efforts indicated the strengths and limitations of many of the system concepts which will be invaluable in future improvement efforts.

SECTION 5
RECOMMENDATIONS

As a result of this development program, a unique dust cloud mass measuring system was conceived and tested. The test experiences yielded a variety of information concerning the advantages and disadvantages of each design aspect. After considering this data and future program needs, it is recommended that refinements include the following:

Canister System

1. Active measurements Additional measurement capability should be added to further define accumulated mass versus altitude and particle size. The consideration of 1) compartments or bins that change with time 2) the capacitance measurement technique and 3) further study of the acoustic sensor (which should give data on particle size), should be pursued. In addition to the new measurement techniques, the effect of moisture content on the measurement should also be assessed.

2. Collection techniques The passive sample collection concept should be further refined to eliminate impact of the particles on the collector chamber walls. With the cyclone separator, an excessive amount of interaction of the particle with the wall occurs with a probable break up of the larger particles. A system involving particle separation by turning the high velocity flow suggested. Such a scheme, would have some design effect

on the capacitance measurement of the accumulated mass, but may permit a smaller sized canister.

3. <u>Parachute system</u> The pre-impact release of a deceleration parachute should be eliminated. Experience has shown that problems of deployment timer accuracy and drop time increment determinations as it pertains to real altitude would be eliminated if the canister could survive a high velocity impact. In addition to this, the canister could measure dust particles all the way to the ground which would increase its scientific effectiveness.

   Observations of canister impacts indicate that if a more durable front end is provided with a crushable outer cylinder the canister could survive impacts of up to 122 meters per second (400 feet per second). Additional design problems resulting from such a change include the closure of the collection chamber both front and aft prior to impact. An impact triggered closure mechanism is suggested as one design approach.

   Having eliminated the timer and practice drop problems, variable drag schemes are also suggested which would provide preprogrammed different descent and cloud penetration times with simple design modifications.

4. <u>Electronic tracking and impact identification</u> An electronic signal identification and impact notification scheme is suggested. With such a system, an electronic signal would be transmitted after the canister is released. This signal would allow the canister to be tracked to and identified on the ground. Advantages of such a technique would be in providing additional penetration position data and ground location data.

<u>Delivery System</u>

1. <u>General</u> If the helicopter delivery system is to be continued, some refinements are necessary. They should include improvements to sighting, time-sequenced approach positioning, actuating lanyard design and communications; however, it is suggested that alternate delivery systems be considered especially if the collection technique results yield a much smaller canister. With a smaller canister, delivery schemes such as a mortar or howitzer powder gun, balloon or rocket motor could be considered. Such delivery systems eliminate the need of active personnel in aircraft above the explosive detonation.

2. <u>Sighting and time-position</u> A computer assisted ground based deployment scheme is suggested. An electronic tracking signal would be used to determine the exact position of the helicopter and would continually advise the aircraft of headings and airspeeds required to reach the

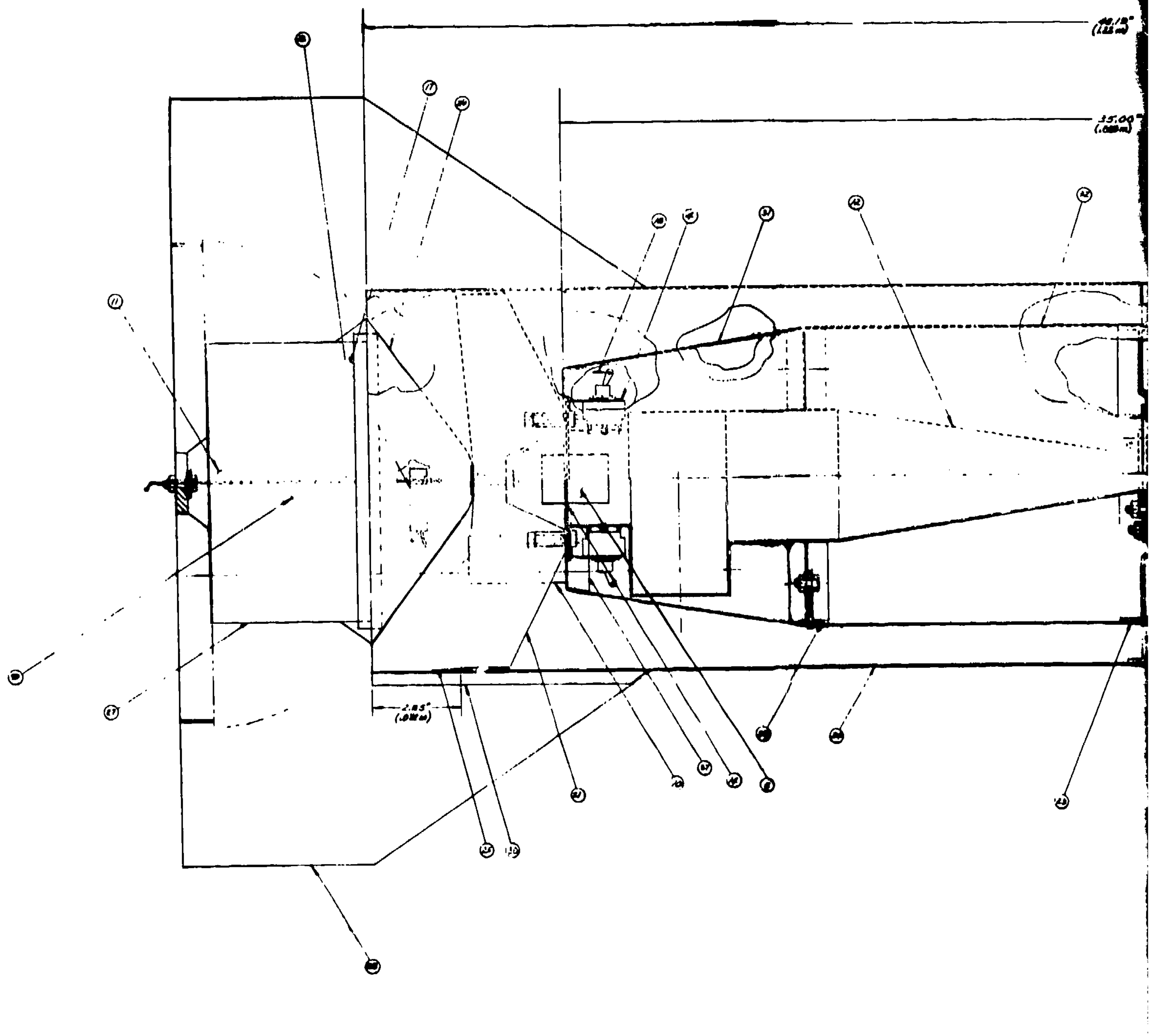
drop-zone at the proper time. Preliminary investigations of the helicopter positioning system have indicated that optical techniques are not well suited and electronic tracking systems should be used.

3. Communication using a two channel FM system is needed. Such a system would allow private communications (essential to (2) preceeding) with a high degree of reliability. Such systems are in use with Army ground-to-air communications with helicopters and could easily be implemented.

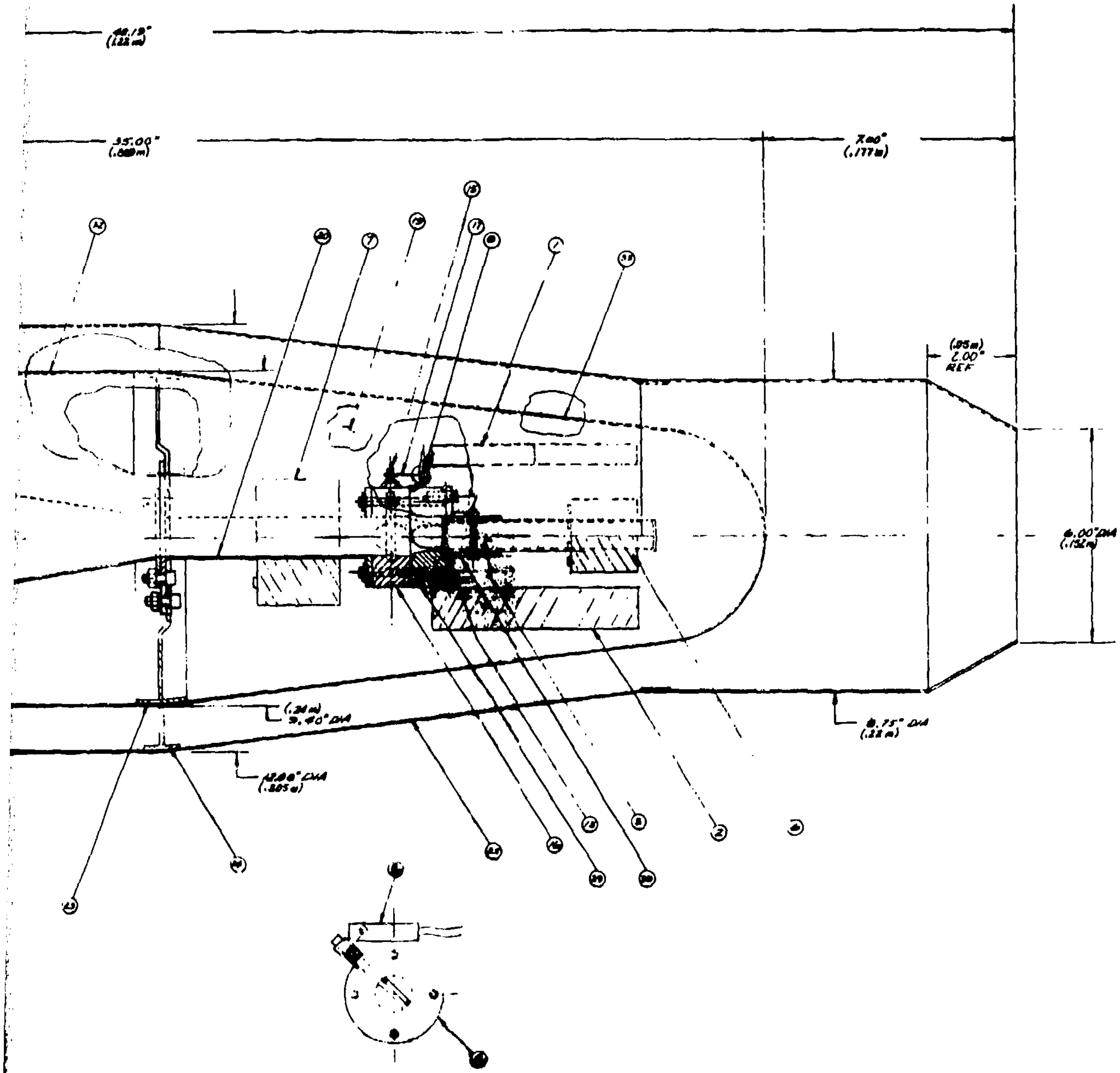
4. A simple, lanyard system to initiate the electronics and smoke flare is recommended. The pull-line must be designed so that it would not interfer with other canisters, the helicopter blades, or engine intakes.

APPENDIX A

The following drawings are the engineering definition of the dust cloud mass measuring canister. All dimensions noted are in inches and degrees as is current engineering practice at Kaman Sciences Corporation. The reader is referred to the beginning of the report for conversion of these units to SI metric values.



35.00"
2.85"



ASSEMBLY DRAWING 450314

SHEET 1 OF 7	REV. X1	DRAWING NUMBER PL450315

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1500 Garden of the Gods Road, Colorado Springs, Colorado

DRAWING MATERIAL & PARTS LIST

CODE IDENT. NO. 21732

TITLE MEASURING SYSTEM, DUST CLOUD

NEXT ASSY. | MODEL

NOTES
SEE SHT 7

NOTES	ITEM NO.	CAT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	DESCRIPTION	001	002	003
	X		4	5	0	3	1	5	-	0	0	0						ASSY DWG	REF	REF	REF
	X		4	3	0	0	4	2										SCHEMATIC	"	"	-
	X		4	5	0	3	1	5	-	0	0	1						SYSTEM ASSY-ACTUAL	X		
	X		4	5	0	3	1	5	-	0	0	2						SYSTEM ASSY-PARACHUTE DUMMY		X	
	X		4	5	0	3	1	5	-	0	0	3						SYSTEM ASSY-FREE FALL DUMMY			X
	1																	ELECTRONICS, SIG. COND	2	2	-
A	2		S	3	0	1												RECORDER	1	-	-
	3																	SENSOR ASSY. (CAP)	1	-	-
B	4																	SWITCH, START-STOP	2	1	-
C	5		1	2	0	-	2	4	-	X	2	-	E	1				RELAY, DELAY, R12 TYPE	1	1	-
D	6																	PWR SUPPLY	1	1	-
E	7																	POWER SUPPLY	1	1	-
F	8		2	8	0	1												GUILLOTINE	3	1	1
G	9																	PARACHUTE-8 FOOT	1	1	1
H	10																	FLARE, WHT, 60 Sec.	1	1	1
H	11																	FLARE, WHT, 60 Sec			
J	12		X	Q	-	3												CYCLONE	1	-	-

FORM NC .38-9

SHEET 1 OF 7 REV. X1 DRAWING NUMBER PL450315

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DRAWING MATERIAL & PARTS LIST

CODE IDENT. NO. 21732

TITLE
MEASURING SYSTEM, DUST CLOUD

NEXT ASSY. | MODEL

NOTES

NOTES	ITEM NO.	CAT	DRAWING NUMBER (1–15)	DESCRIPTION	QUANTITY -001	002	003
	13						
	14			FILTER	1	-	-
	15			CLOSURE LEVER	1	-	-
	16			CLOSURE ASSY	1	1	1
	17			WIRE, TRIGGER	A/R	A/R	A/R
	18			LANYARD SWITCH ACTUATING	A/R	A/R	A/R
	19			FOAM, CASTABLE	A/R	A/R	A/R
	20			CHAMBER, SETTLING	1	-	-
	21	4	10245	RIB, AFT	1	1	1
	22	4	10246	RIB, MID	1	1	1
	23	4	10250	RIB, FWD	1	1	1
	24			SPACER	3	3	3
	25			CLOSURE, STOP	4	4	4
	26	4	10248-001	FLEXIBLE CLOSURE	1	1	1
	27	4	50318-001	HOUSING, PARACHUTE	1	1	1
	28	4	0316-000	STABILIZING-FIN ASSY	1	1	1
	29						
	30			GUIDE, STABILIZING FIN ASSY	8	8	8
	31	4	10249-004	SKIN, AFT, INSTR. POD	1	1	1

FORM NC .M-9

SHEET 2 OF 7 | REV. X1 | DRAWING NUMBER PL450315

KAMAN SCIENCES CORPORATION
1500 Garden of the Gods Road, Colorado Springs, Colorado

DRAWING MATERIAL & PARTS LIST

CODE IDENT. NO. 21732

TITLE
MEASURING SYSTEM, DUST CLOUD

NEXT ASSY. | MODEL

NOTES

NOTES	ITEM NO.	CAT	DRAWING NUMBER	DESCRIPTION	QUANTITY 001	002	003
	32		41024 9-003	SKIN, MD INSTR. POD	1	1	1
	33		41024 9-001 &-002	NOSECONE, INSTR. POD	1	1	1
	34		45031 7-001 &-C02	SHROUD, OUTER-AFT	1	1	1
	35		41025 3-001	SHROUD, OUTER, MID	1	1	1
	36						
	37		41024 7	FLANGE, CYCLONE MTG.	1	1	1
	38		41025 2-001	SHROUD, OUTER, INLET	1	1	1

SHEET 3 OF 7 | REV. X1 | DRAWING NUMBER PL450315

FORM NC .■-9

SHEET 4 OF 7 | REV. X1 | DRAWING NUMBER PL450315

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DRAWING MATERIAL & PARTS LIST

CODE IDENT. NO. 21732

TITLE: MEASURING SYSTEM DUST CLOUD

NEXT ASSY. | MODEL | NOTES

NOTES	ITEM NO.	CAT	DRAWING NUMBER	DESCRIPTION	QUANTITY 001	002	003
				1/4-20UNC ALLEN SOCKET HEAD CAP SCREW X 3" LONG	6	6	6
				1/8 x 3/8 POP RIVET	20	20	20
				1/8 x 1/4 POP RIVET	100	100	100
				3/16 x 7/16 POP RIVET	350	350	350
				VACUUM VALVE CABLE	1 FT	-	-
				VACUUM VALVE-NUPRD C7-304 24VEO	1	-	-
				1/8 STEEL AIRCRAFT CABLE	3	3	3 FT
				1/8 STEEL CABLE SLEEVES	2	2	2
				1/8" STEEL CABLE CLAMPS	1	1	1
				SMOKE FLARE BRACKET	1	1	1
				2 1/2" DIA HOSE CLAMP	2	2	-
				MYLAR WRAP	A/R	-	-
				ALUM FOIL WRAP	A/R	-	-
				POLY BAG	1	-	-
				SET SCREW-VACUUM VALVE 8-32 UNC x 1/8	2	-	-
				TENSION SPRING - 8" LONG	1	-	-
				TORSION SPRING (DOOR CLOSURE)	3	-	-
				NEOPRENE RUBBER 1/8" THICK	A/R	-	-
				2" DIA. HOSE CLAMP	2	2	-

SHEET 4 OF 7 | REV. X1 | DRAWING NUMBER PL450315

FORM KC .18-8

KAMAN SCIENCES CORPORATION
1500 Garden of the Gods Road, Colorado Springs, Colorado

DRAWING MATERIAL & PARTS LIST

CODE IDENT. NO. 21732

TITLE: MEASURING SYSTEM, DUST CLOUD

NEXT ASSY. | MODEL

NOTES

NOTES	ITEM NO.	CAT	DRAWING NUMBER	DESCRIPTION	QUANTITY 001	002	003	
				RUBBER CEMENT	A/R	-	-	
				BATTERIES 1 1/2 V	5	5	-	
				BATTERIES 9V	6	6	-	
				CONNECTOR ARCHER	1	1	-	
				RTV-LEAD POTTING	A/R	A/R	-	
				1/4-20 UNCx3/4 HEX HD CAP SCREW	12	12	12	
				1/4-20 UNCx2 1/2" LONG ALLEN ~~SOCKET HEAD CAP SCREW VAC VALVE~~	4	-	-	
				CAL SWITCH ARCHER 275-326	1	1	-	
				EYEBOLT 3/8 - 16 x 2"	1	1	1	
				EYEBOLT WASHER 3/8" HOLE	1	1	1	
				EYEBOLT (SMALL) #10-32	1	1	1	
				EYEBOLT NUT #10-32	2	2	2	
				EYEBOLT LOCK WASHER	1	1	1	
				1/4-20 NUTS	22	22	22	
				1/4-20 LOCK NUTS	16	12	12	
				FISH LINE -25# TEST	5	5	5	FT
				1/8 NYLON CORD	20	20	20	FT
				1/4 NYLON CORD	3	8	8	FT
				5 MIN EPOXY	A/R	A/R	A/R	

SHEET 5 OF 7 | REV X1 | DRAWING NUMBER PL450315

KAMAN SCIENCES CORPORATION
1500 Garden of the Gods Road Colorado Springs, Colorado

DRAWING MATERIAL & PARTS LIST

CODE IDENT NO. 21732

TITLE: MEASURING SYSTEM, DUST CLOUD

NEXT ASSY. | MODEL

NOTES

NOTES	ITEM NO.	CAT	DRAWING NUMBER	DESCRIPTION	QUANTITY 001
				SMOKE BOMBLET	
				SMOKE FLARE	1
				LEAD	A/R
				FENCE POST CAP	1
				GUTTER NAIL	1
				FIN	3
				WIRE	A/R
				5 MIN EPOXY	A/R

FORM NO. 15-1

SHEET 6 OF 7 REV. X1 DRAWING NUMBER PL450315

KAMAN SCIENCES CORPORATION 1500 Garden of the Gods Road Colorado Springs Colorado	DRAWING MATERIAL & PARTS LIST	NEXT ASSY.	MODEL	NOTES
CODE IDENT NO. 21732	TITLE MEASURING SYSTEM, DUST CLOUD			

NOTE:

A BELL SYSTEMS INC. 716 NO. WEBER COLORADO SPRINGS, CO 80903

B

C POTTER-BROMFIELD

D

E

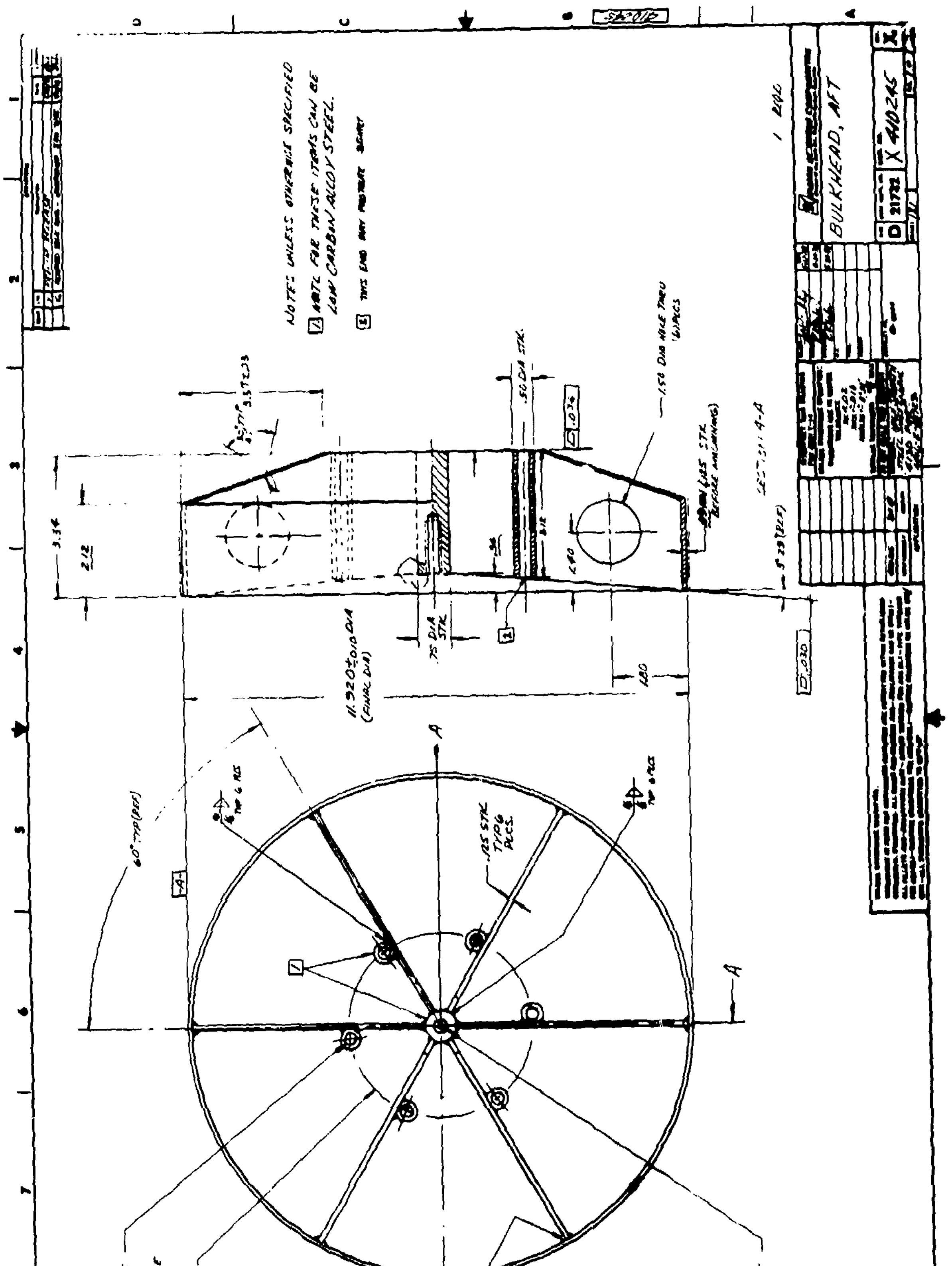
F HOLEX INC. 2751 SAN JUAN ROAD HOLLISTER CALIF. 95023

G LADY-MAC CORSETCO BUFFALO, N.Y.

H SUPERIOR SIGNAL CO. INC. WEST GREYSTONE ROAD, SPOTSWOOD, N.J. 08884

I

J FISHER-KLOSTERMAN, INC. 2901 MAGAZINE ST., LOUISVILLE, KY 40211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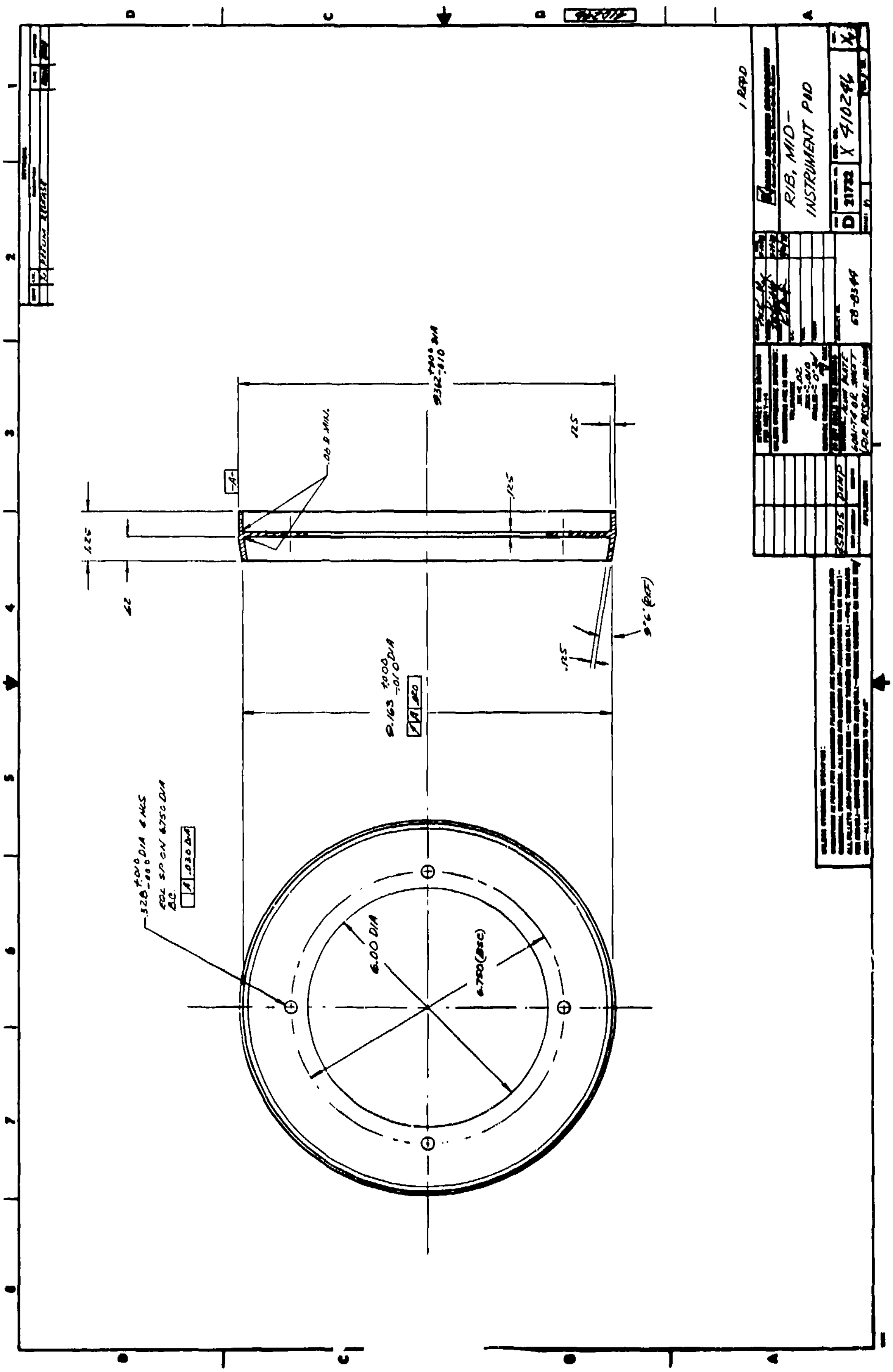
1.50 DIA HOLE THRU (6) PLCS
4.312 BSC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INSTRUMENT POD
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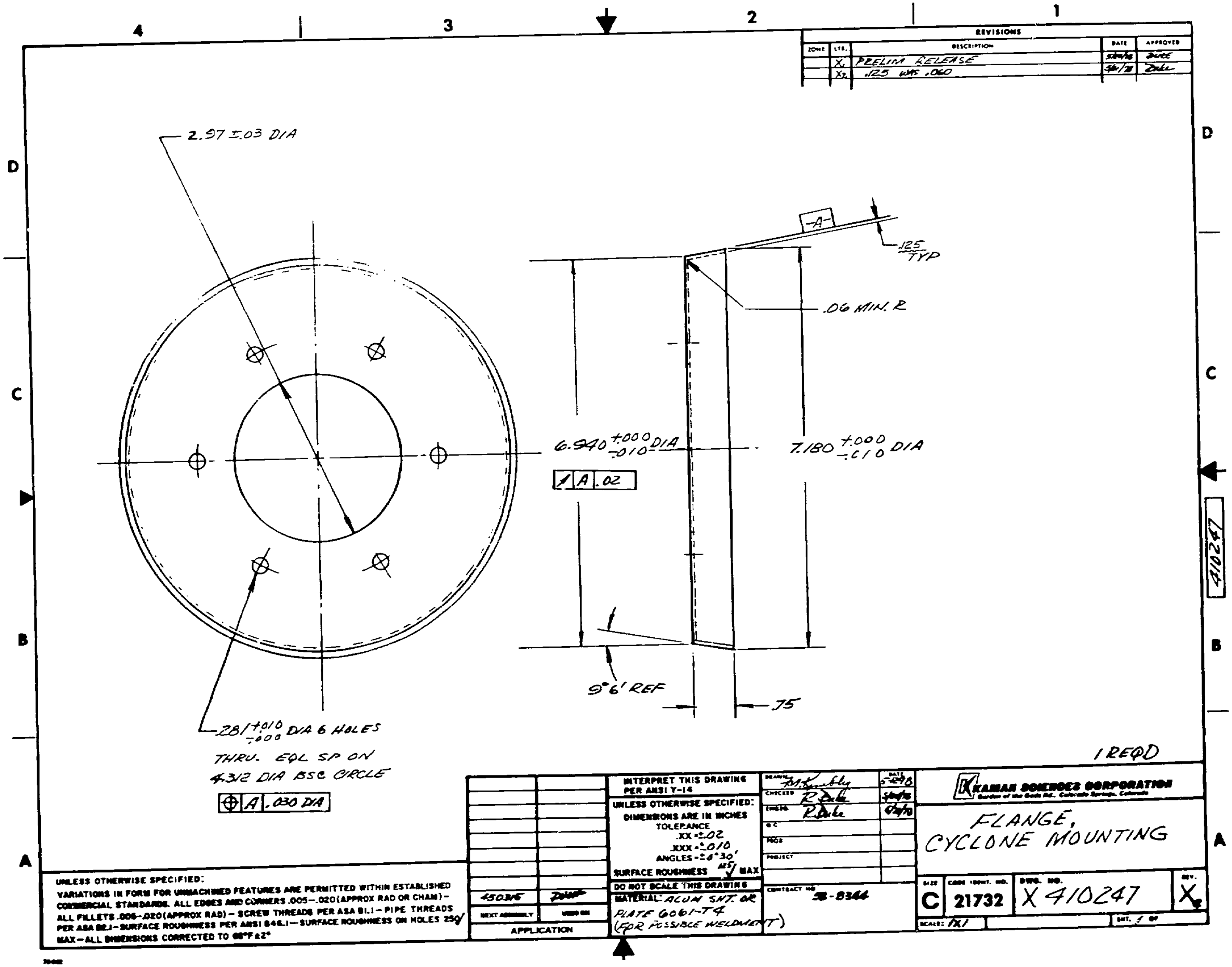
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-A-
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6.940 +.000 -.010 DIA
A .02
7.180 +.000 -.010 DIA
9°6' REF
.75
.281 +.010 -.000 DIA 6 HOLES
THRU. EQL SP ON
4.312 DIA BSC CIRCLE
A .030 DIA
1 REQD
UNLESS OTHERWISE SPECIFIED:
VARIATIONS IN FORM FOR UNMACHINED FEATURES ARE PERMITTED WITHIN ESTABLISHED COMMERCIAL STANDARDS. ALL EDGES AND CORNERS .005-.020 (APPROX RAD OR CHAM) - ALL FILLETS .005-.020 (APPROX RAD) - SCREW THREADS PER ASA B1.1 - PIPE THREADS PER ASA B2.1 - SURFACE ROUGHNESS PER ANSI B46.1 - SURFACE ROUGHNESS ON HOLES 250 MAX - ALL DIMENSIONS CORRECTED TO 68°F±2°
450316
NEXT ASSEMBLY
USED ON
APPLICATION
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UNLESS OTHERWISE SPECIFIED:
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.XXX = ±.010
ANGLES = ±0°30'
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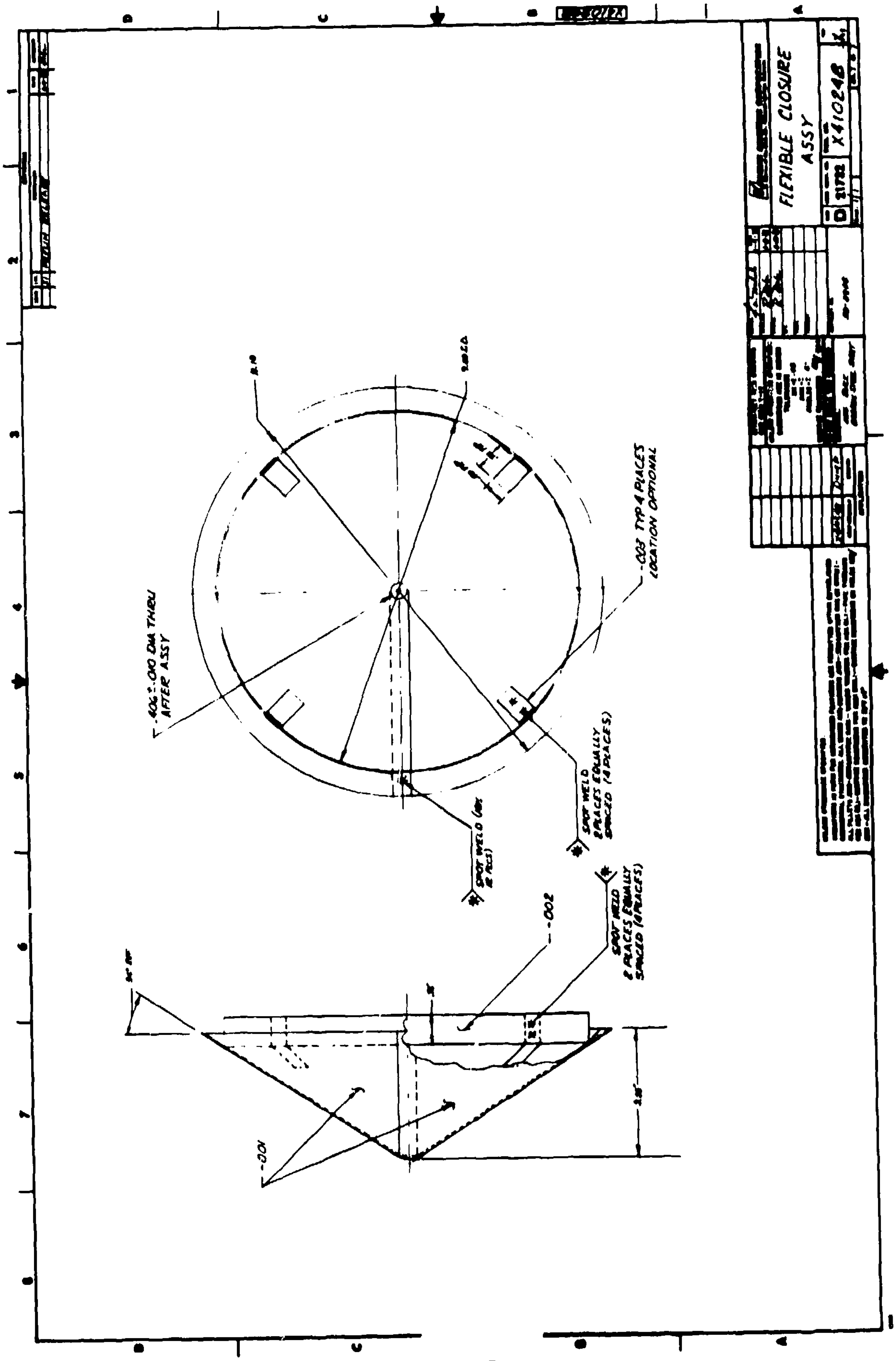
DRAWN
CHECKED
ENGRG
QC
PROJECT
CONTRACT NO
DATE
KAMAN SCIENCES CORPORATION
Garden of the Gods Rd. Colorado Springs, Colorado
FLANGE, CYCLONE MOUNTING
SIZE C
CODE IDENT. NO. 21732
DWG. NO. X 410247
REV. X₁
SCALE: 1X1
SHT. 1 OF
410247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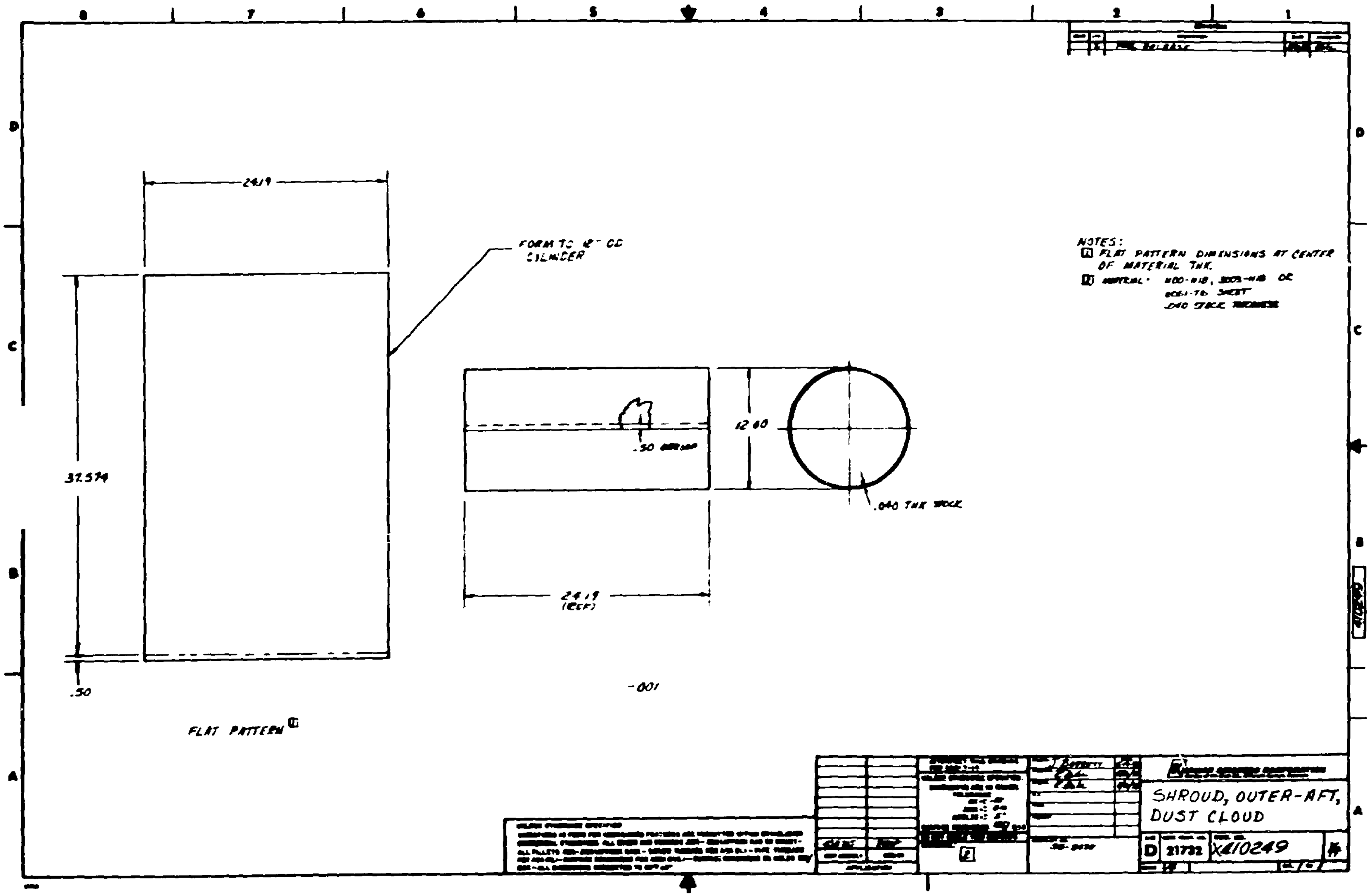
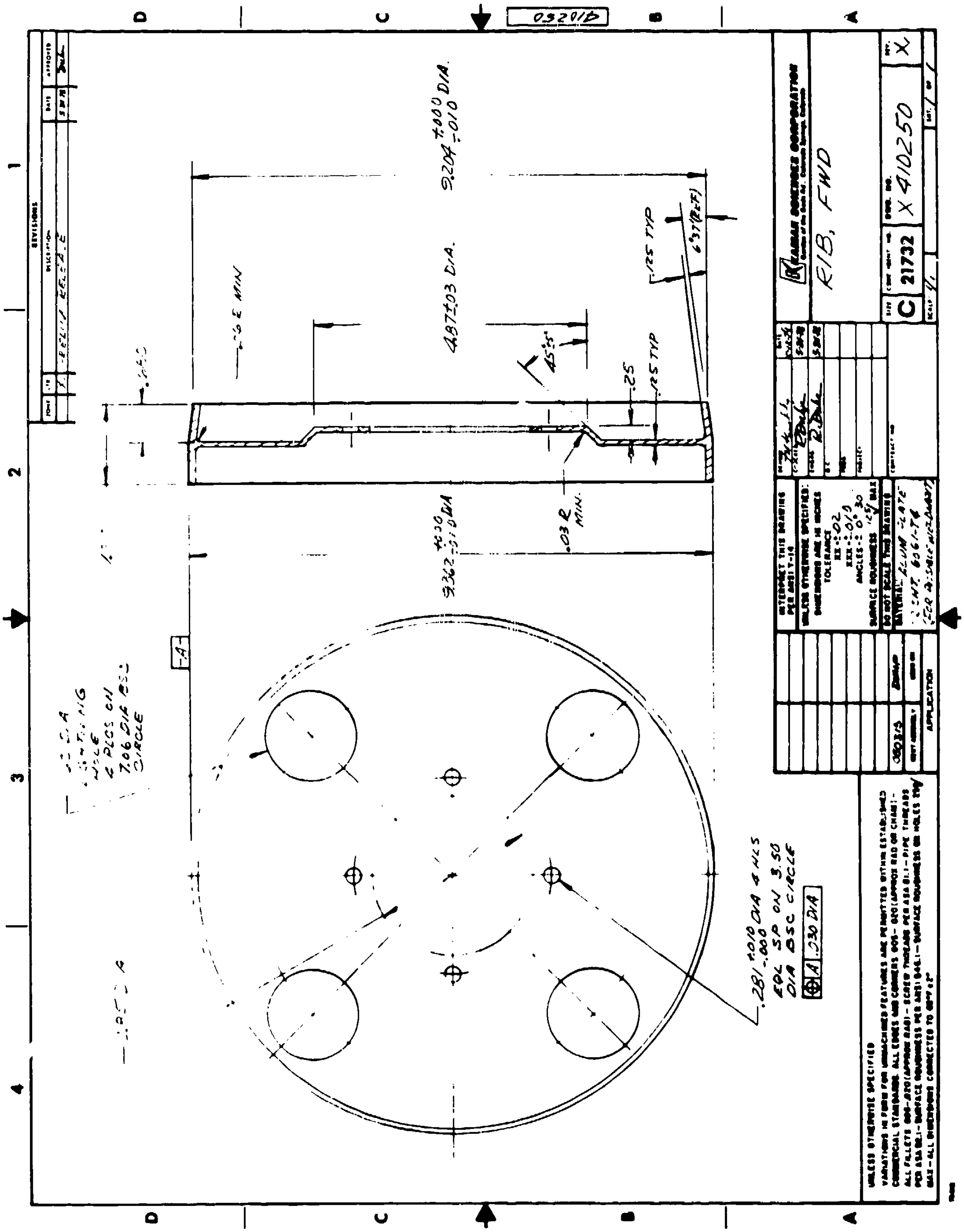
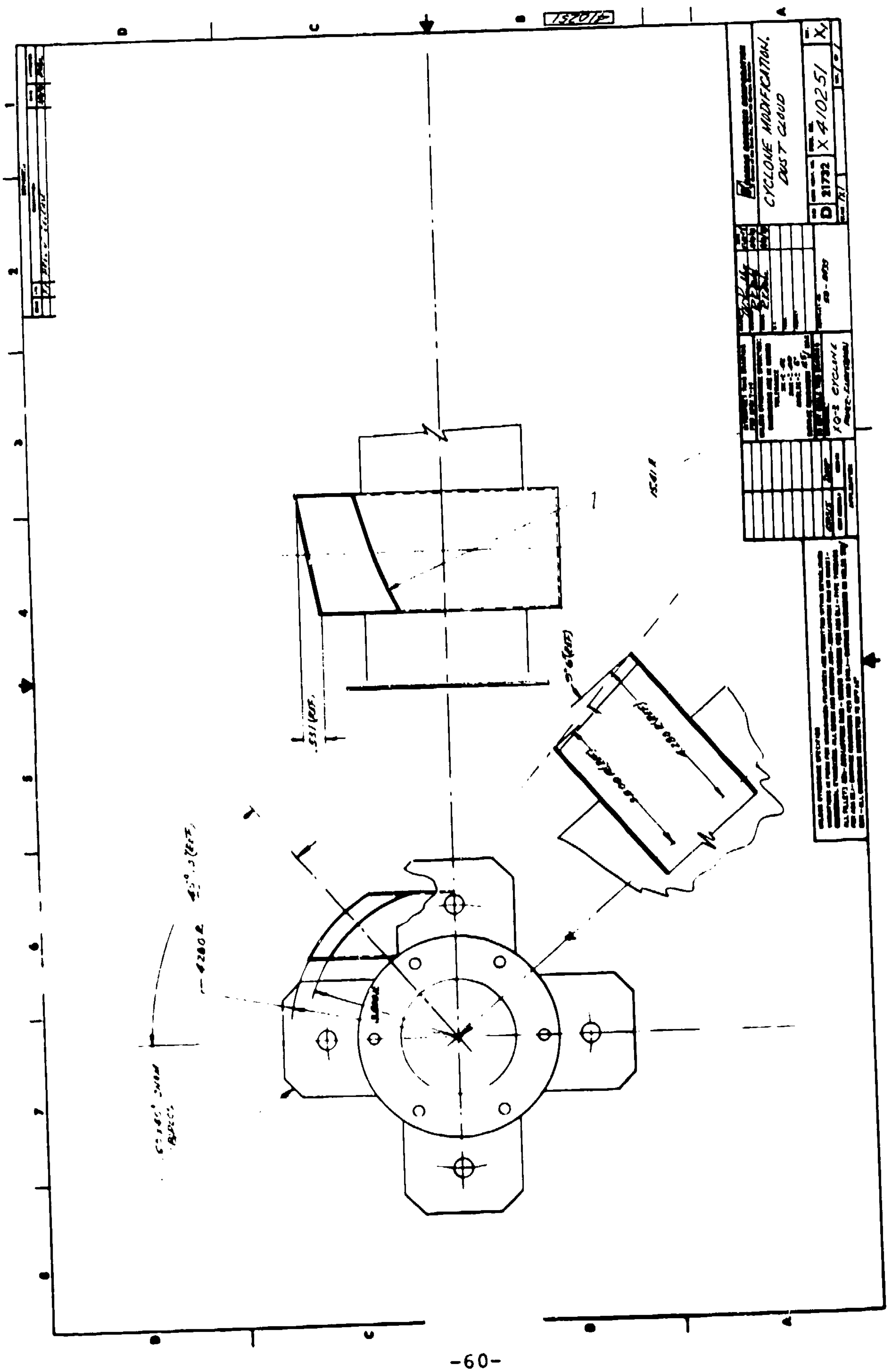
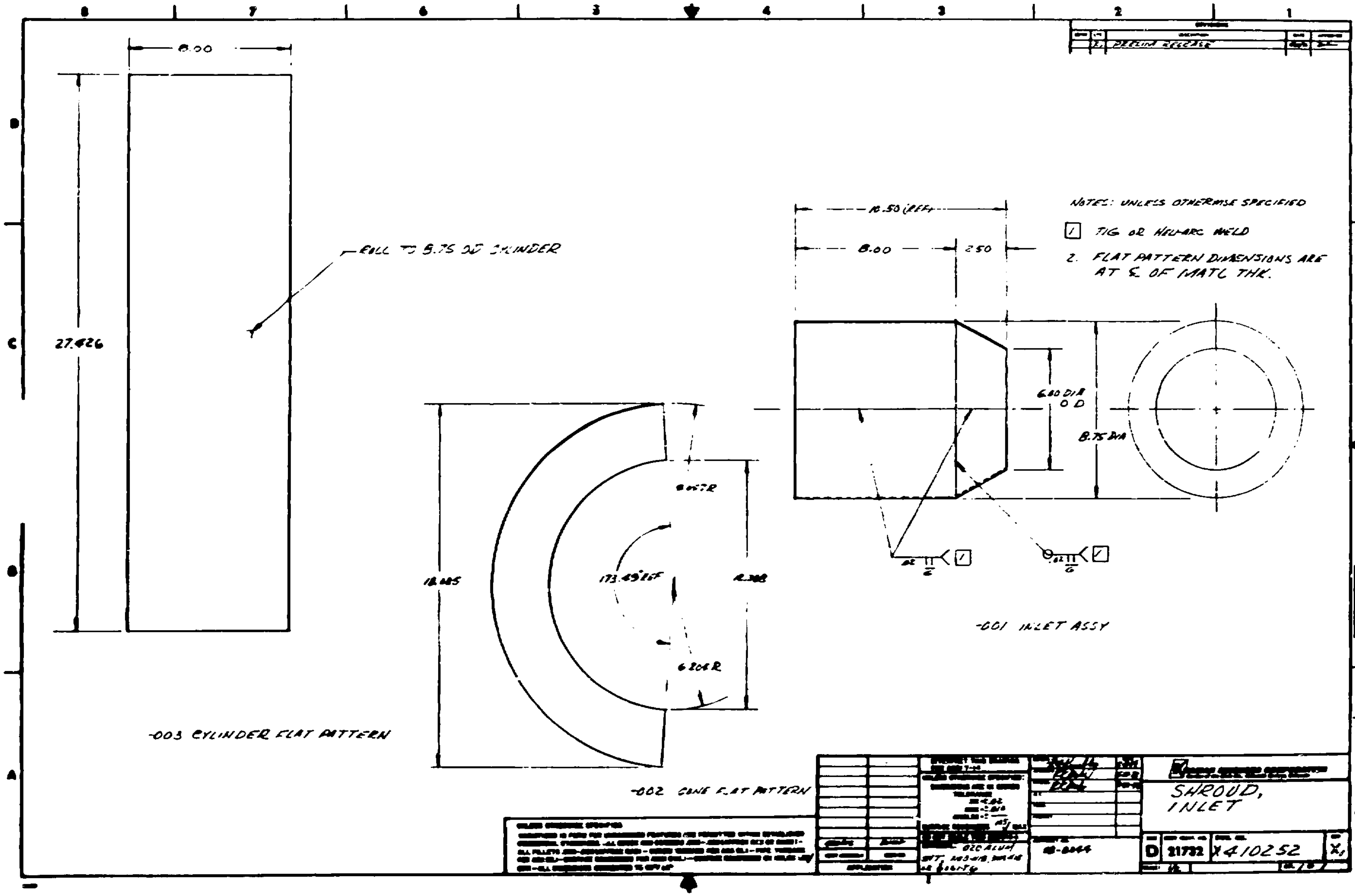
SPACED (8 PLACES)
SPOT WELD (8 PLCS)
-002
SPOT WELD
2 PLACES EQUALLY
SPACED (8 PLACES)
-001

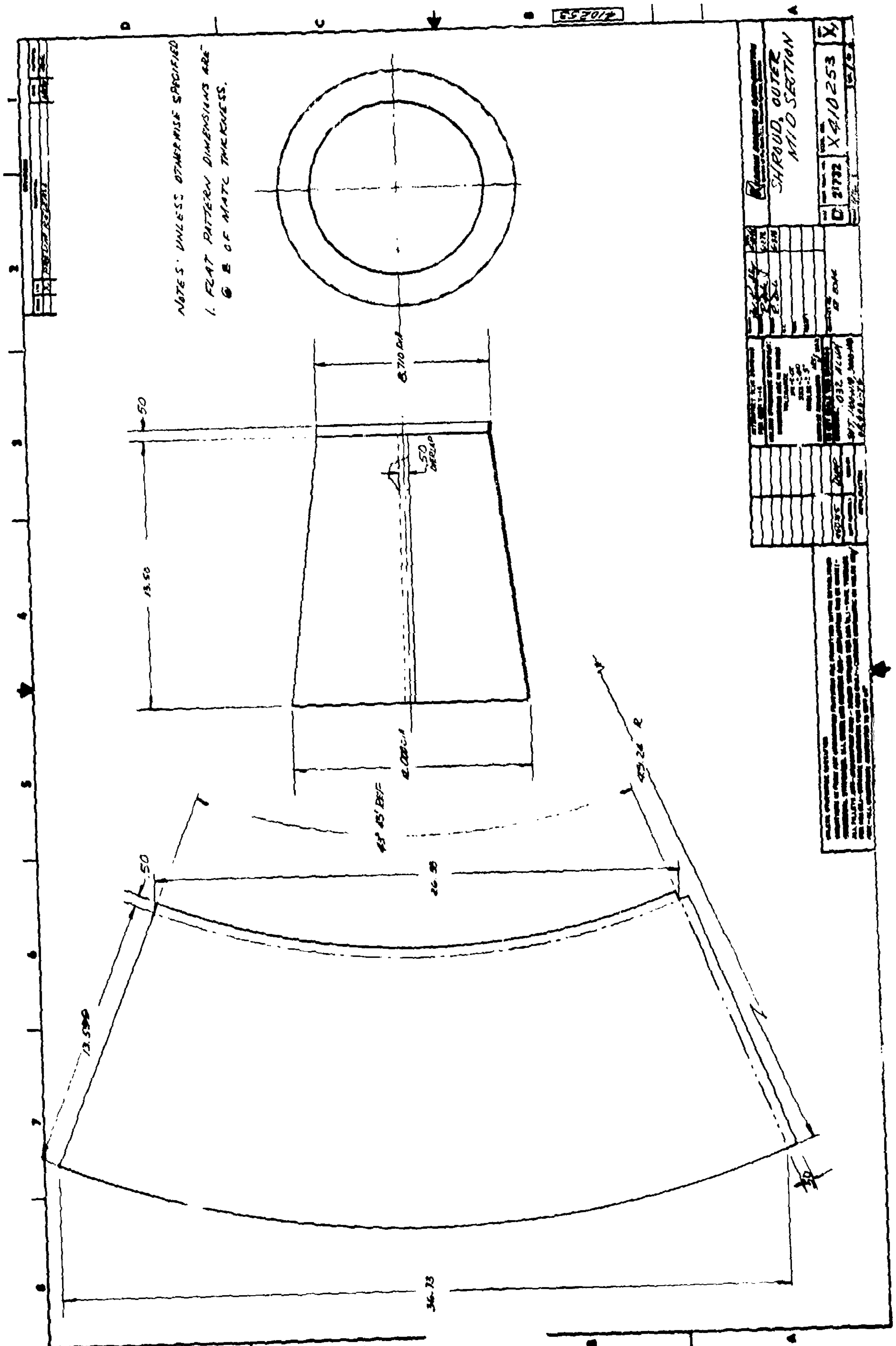


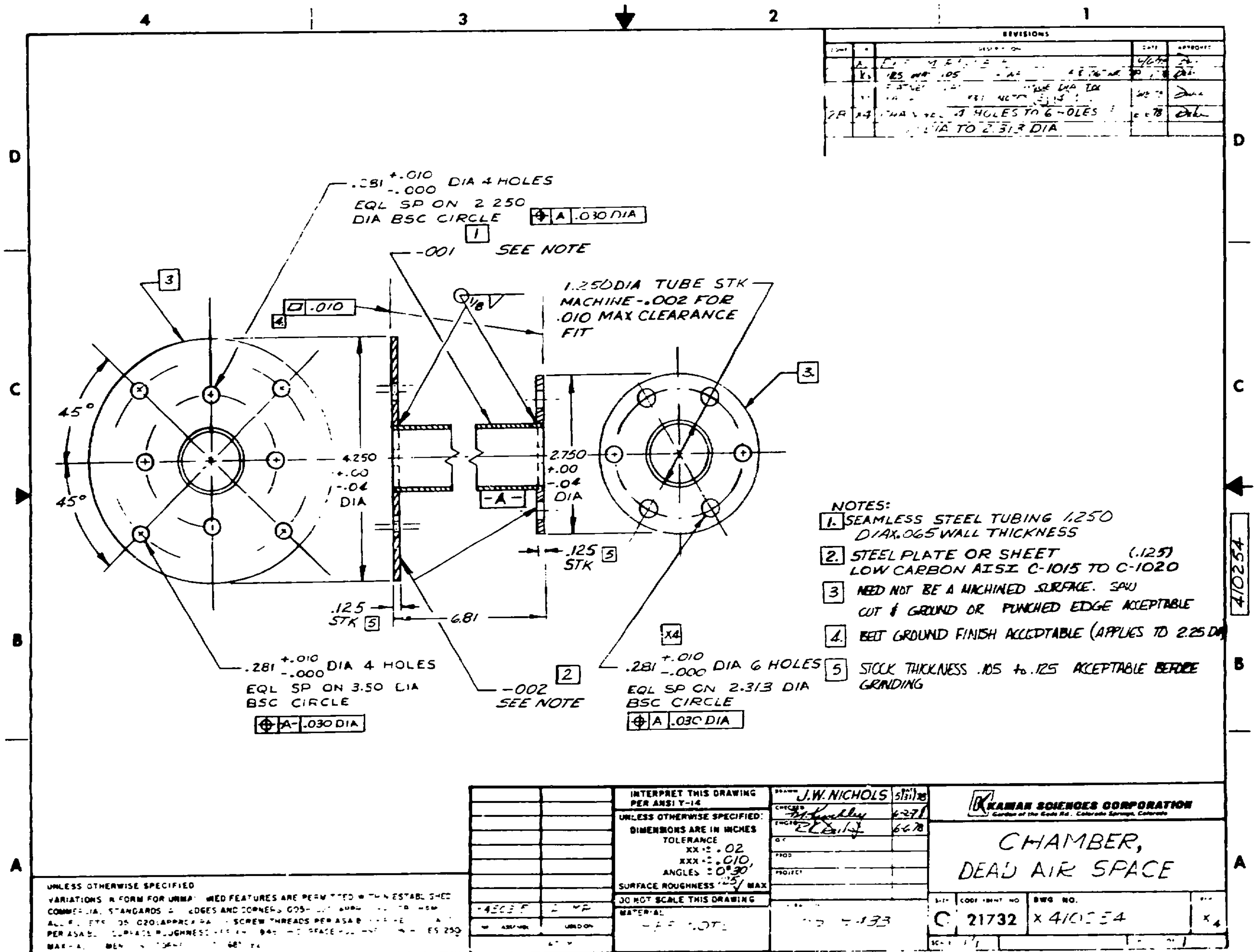
NOTES:
1 FLAT PATTERN DIMENSIONS AT CENTER OF MATERIAL THK.
2 MATERIAL: 6061-T6 SHEET .040 STOCK THICKNESS
FORM TO 12" OD CYLINDER
24.19
31.574
.50
FLAT PATTERN 1
12.00
.50 OVERLAP
.040 THK STOCK
24.19 (REF)
-001
SHROUD, OUTER-AFT, DUST CLOUD
D
21732
X410249


REVISIONS
KAMAN SCIENCES CORPORATION
RIB, FWD
21732
X 410250
4.87±.03 DIA.
.125 TYP
.25
.03 R MIN.
.281 +.010 -.000 DIA 4 HLS EQL SP ON 3.50 DIA BSC CIRCLE
-A-
INTERPRET THIS DRAWING PER ANSI Y 14
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCE
DO NOT SCALE THIS DRAWING
APPLICATION
UNLESS OTHERWISE SPECIFIED


CYCLONE MODIFICATION,
DUST CLOUD
D
21732
X 410251


NOTES: UNLESS OTHERWISE SPECIFIED
1. TIG OR HELI-ARC WELD
2. FLAT PATTERN DIMENSIONS ARE AT ℄ OF MATL THK.
10.50 (REF)
8.00
2.50
6.80 DIA O D
8.75 DIA
-001 INLET ASSY
173.49° REF
6.204 R
18.485
-002 CONE FLAT PATTERN
ROLL TO 8.75 OD CYLINDER
8.00
27.426
-003 CYLINDER FLAT PATTERN
SHROUD, INLET
D
21732
X410252
.020 ALUM
232017


NOTES: UNLESS OTHERWISE SPECIFIED
1. FLAT PATTERN DIMENSIONS ARE @ ℄ OF MATL THICKNESS.
SHROUD, OUTER MID SECTION
X410253
13.50
26.90
36.73



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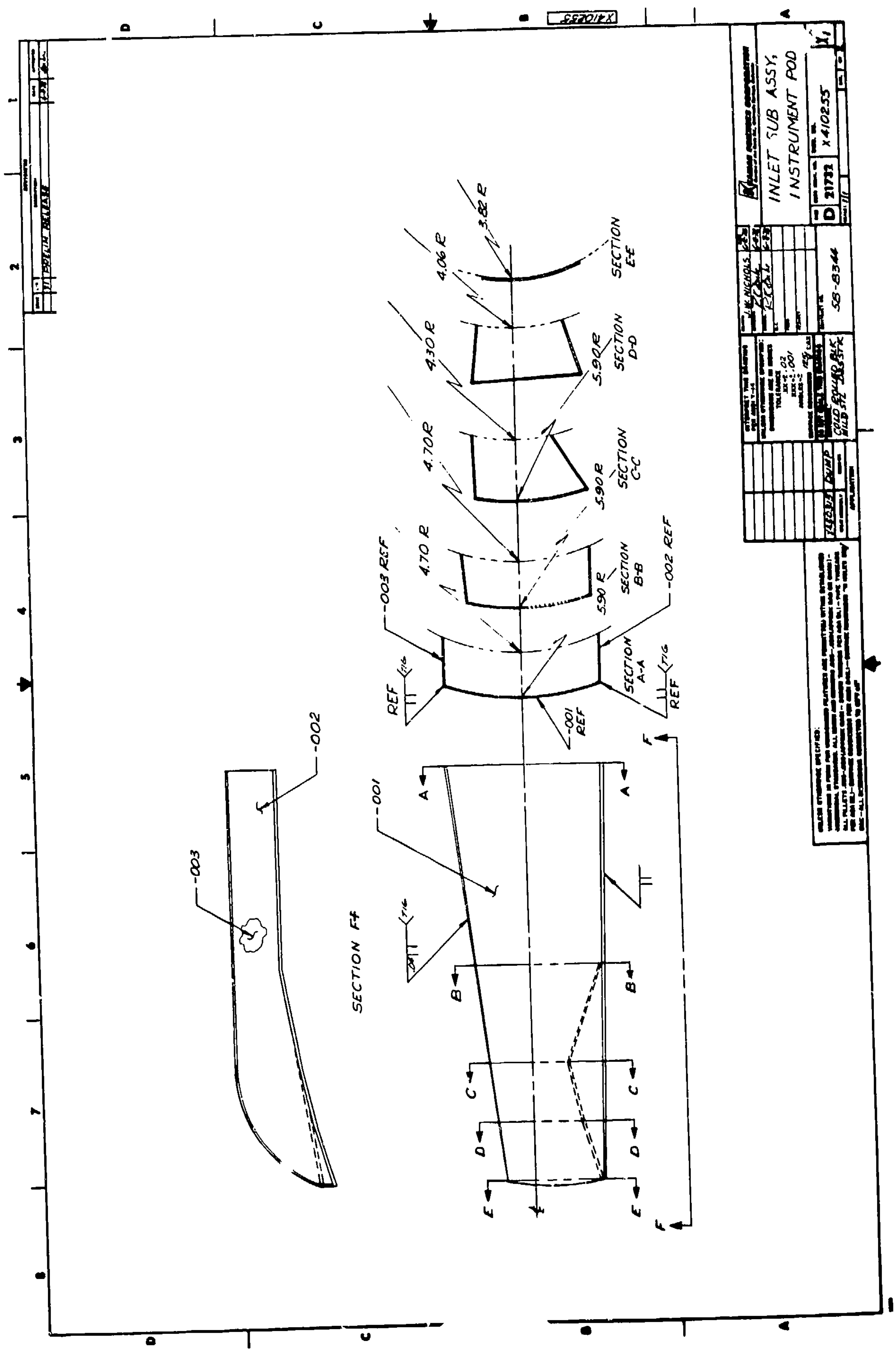
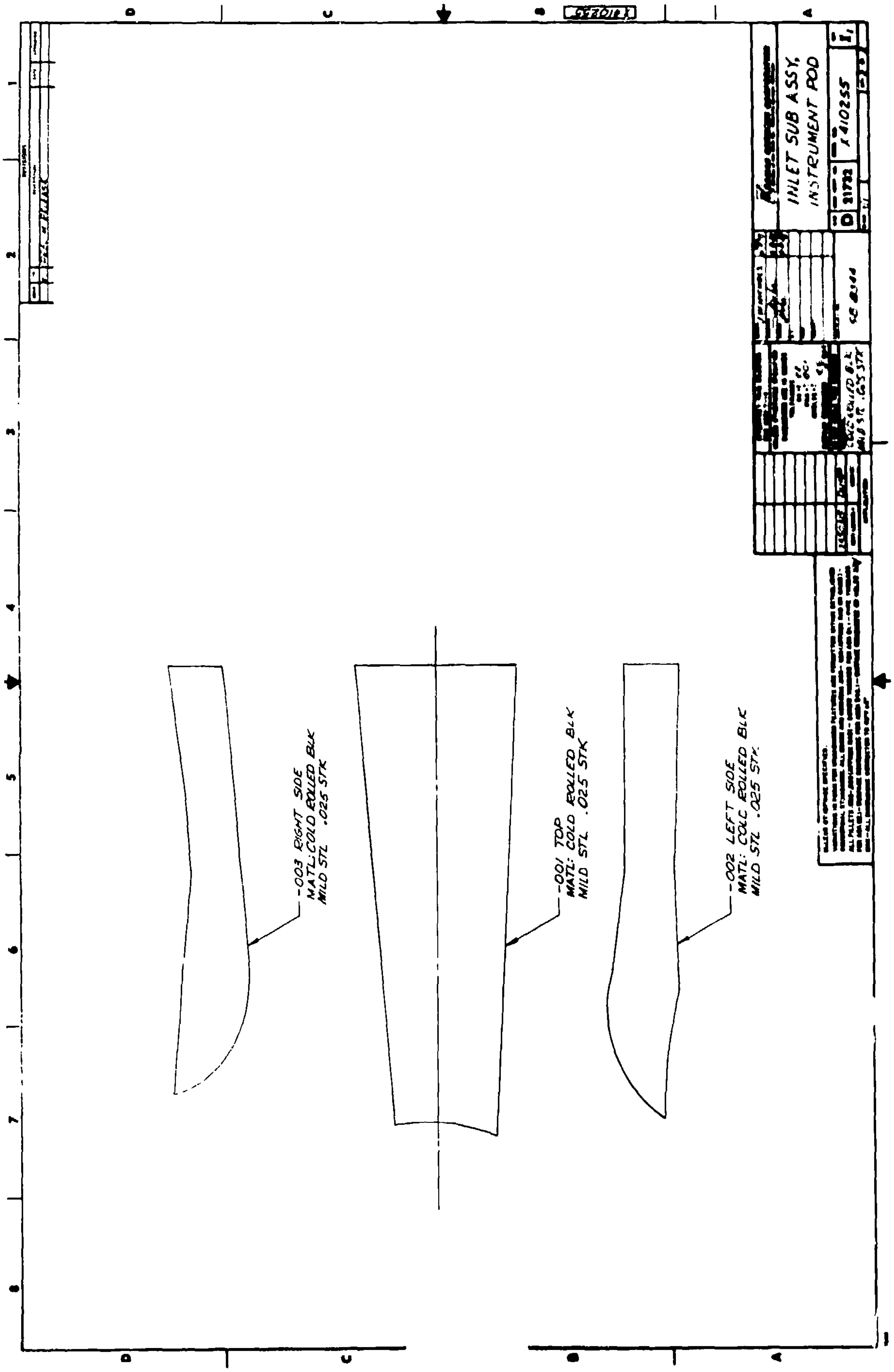
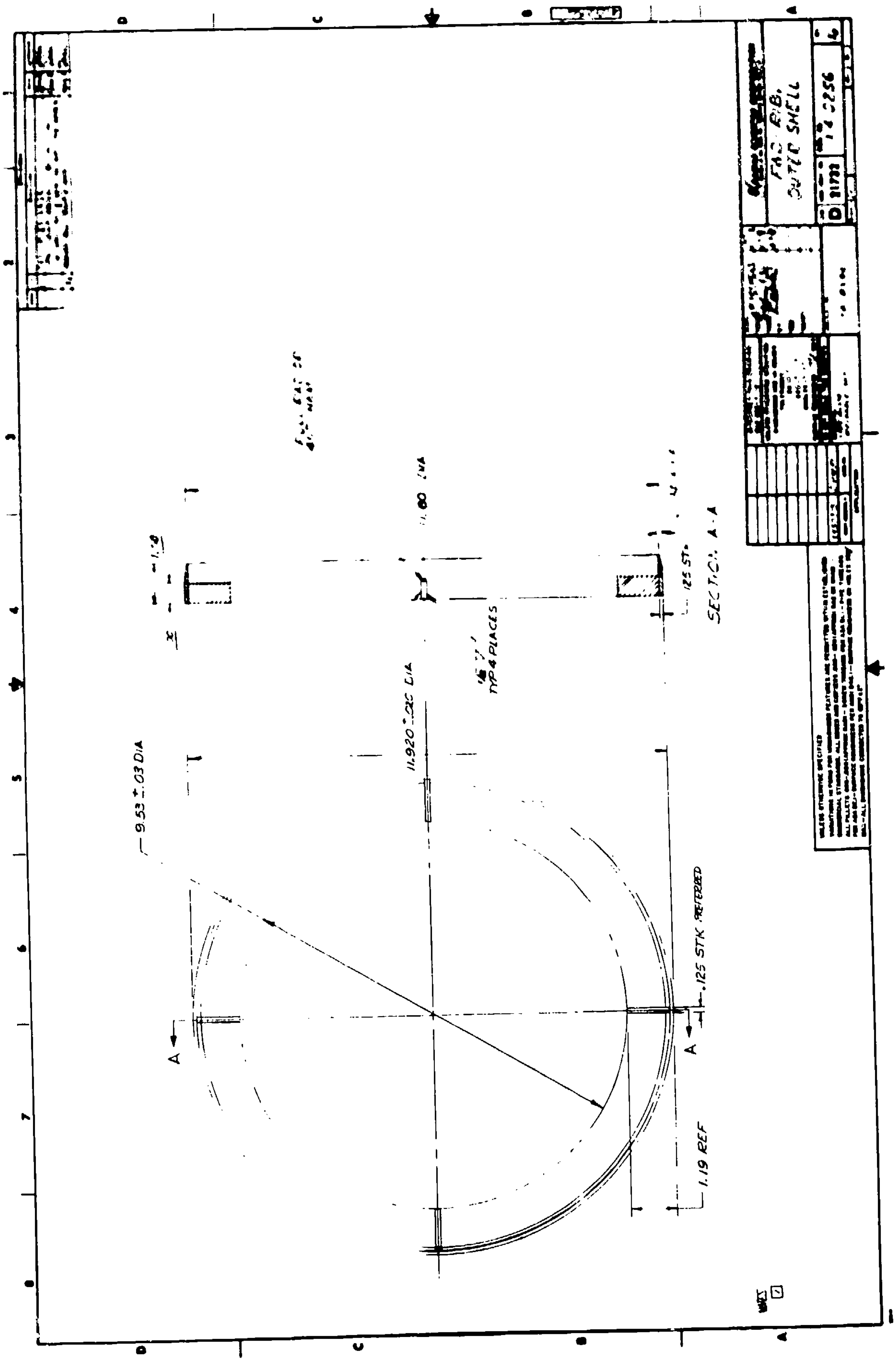
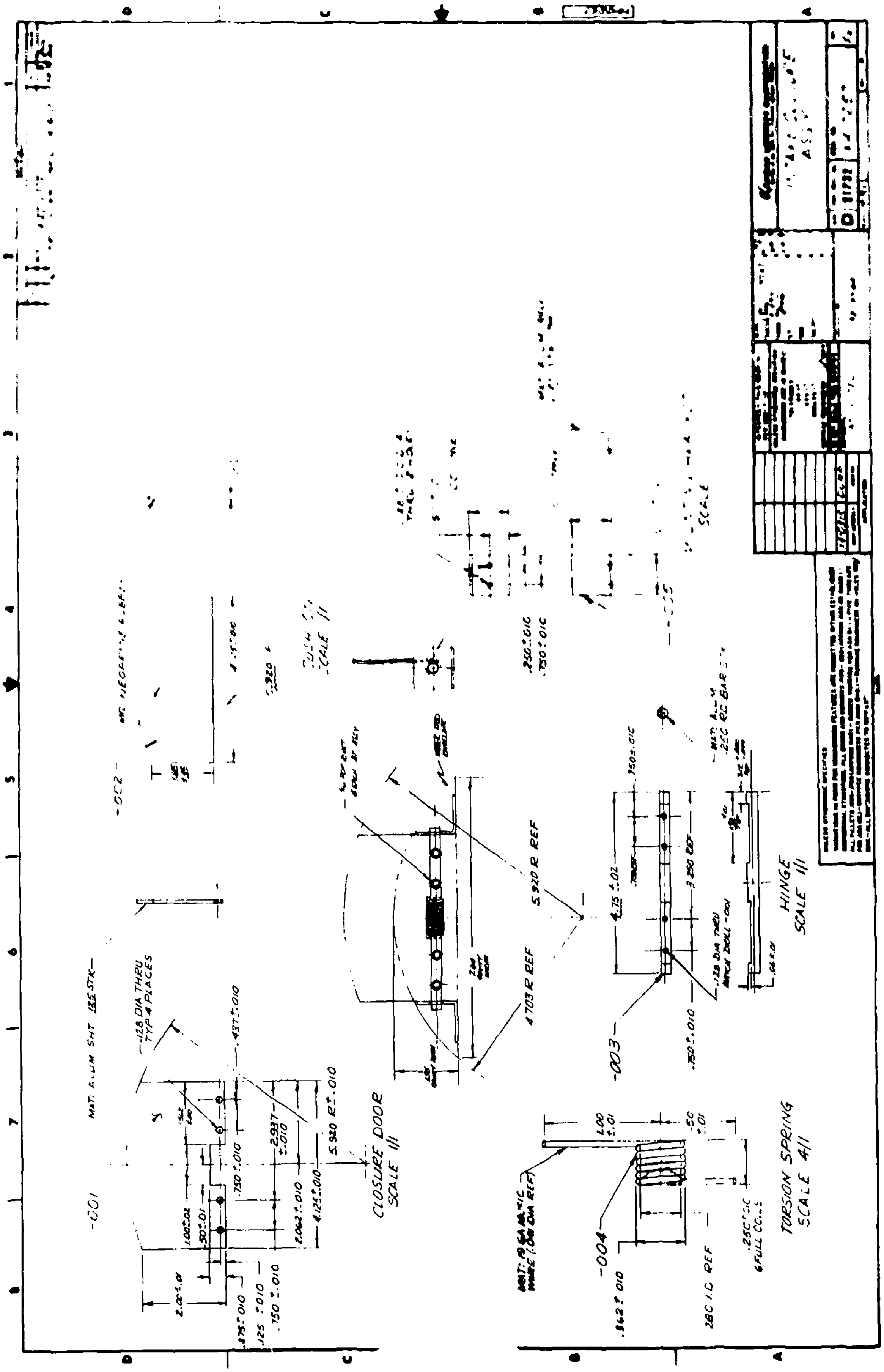

INLET SUB ASSY, INSTRUMENT POD
X410255
21732
SB-8344
J.W. NICHOLS
SECTION A-A
SECTION B-B
SECTION C-C
SECTION D-D
SECTION E-E
SECTION F-F
-001
-002
-003
-001 REF
-002 REF
-003 REF
REF
3.82 R
4.06 R
4.30 R
4.70 R
5.90 R

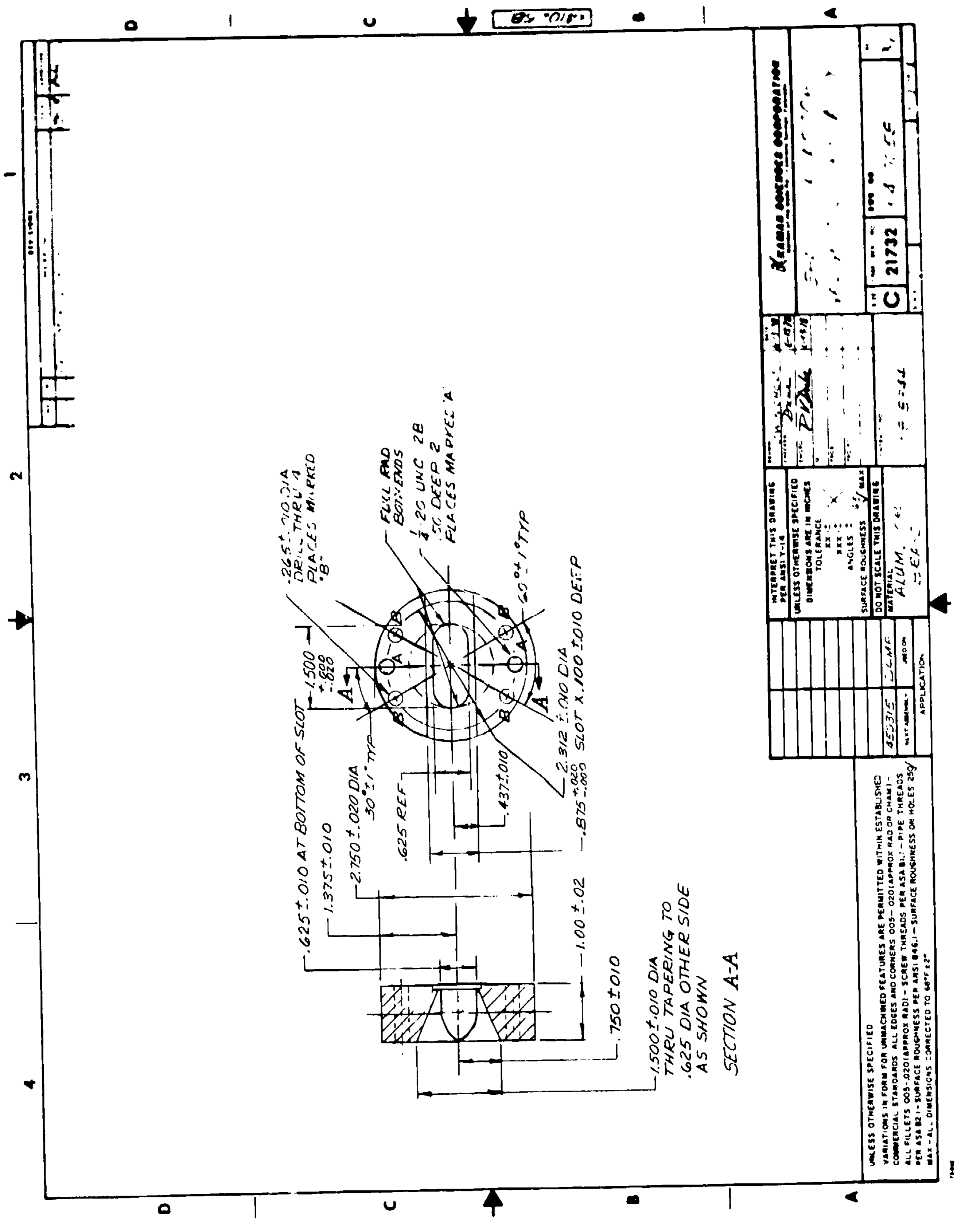


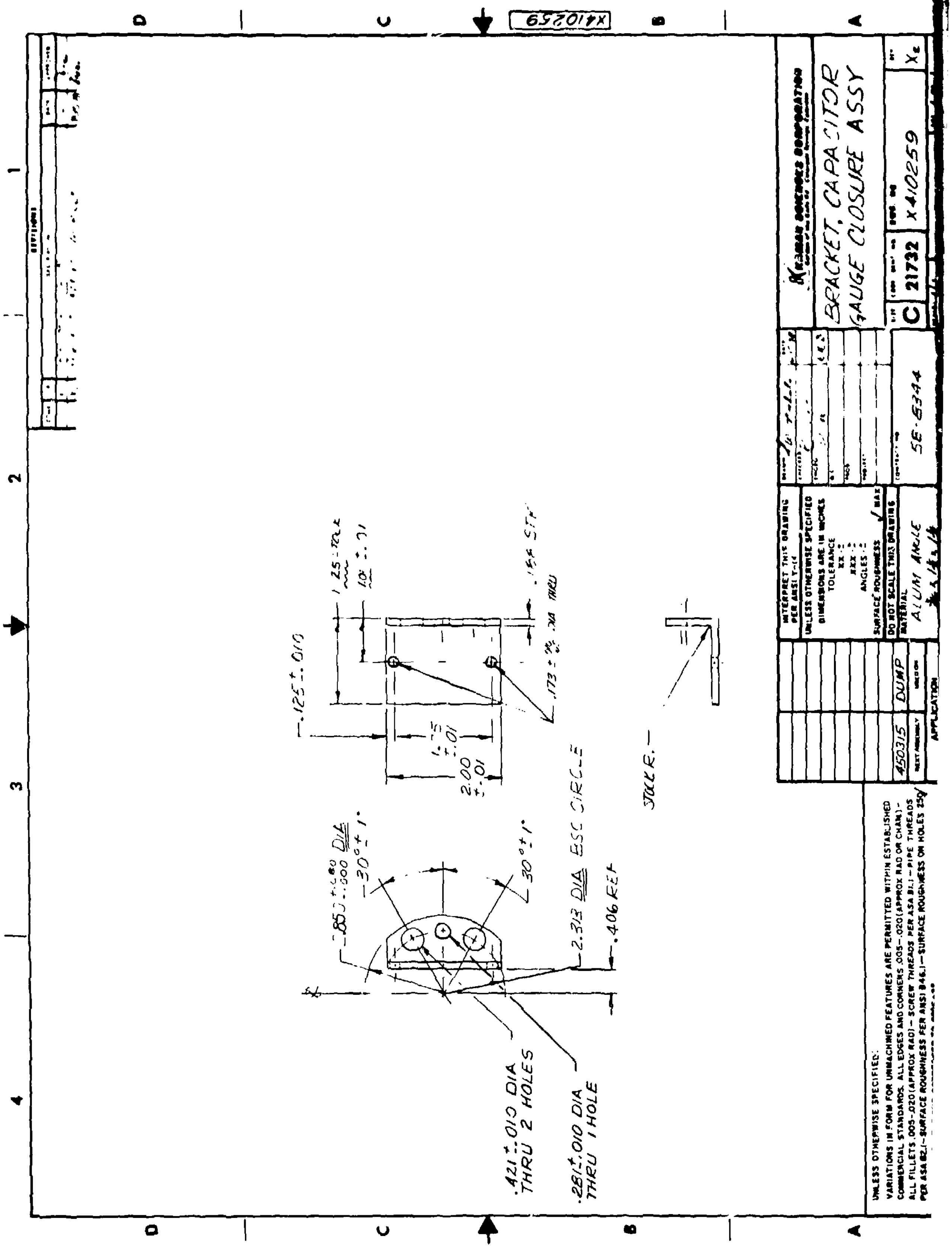
INLET SUB ASSY,
INSTRUMENT POD
X410255
D
21782
-003 RIGHT SIDE
MATL: COLD ROLLED BLK
MILD STL .025 STK
-001 TOP
MATL: COLD ROLLED BLK
MILD STL .025 STK
-002 LEFT SIDE
MATL: COLC ROLLED BLK
MILD STL .025 STK

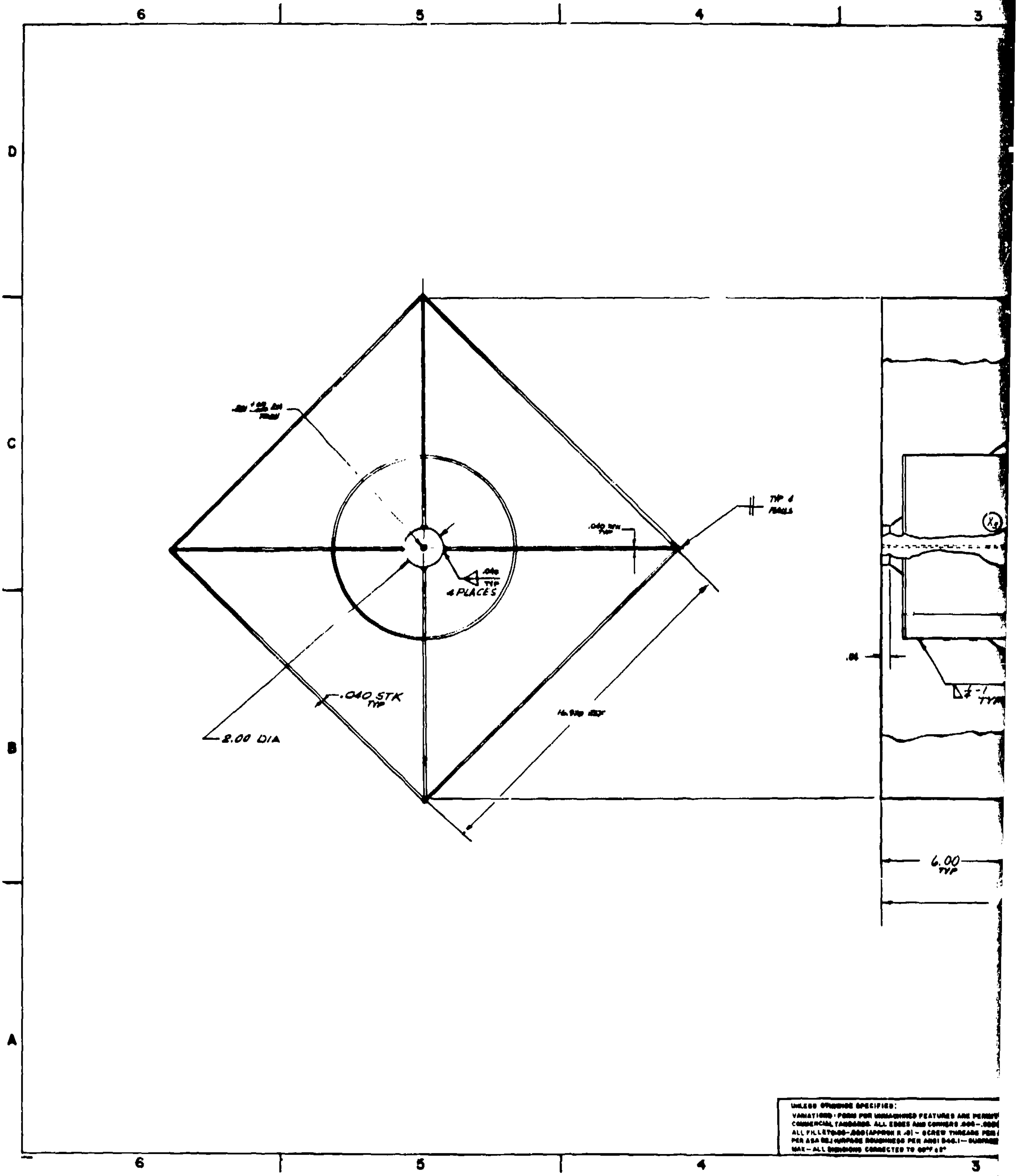


9.53 ± .03 DIA
TYP 4 PLACES
SECTION A-A
1.19 REF
.125 STK PREFERRED
A
A
FAB. RIB,
OUTER SHELL


-001
MAT. ALUM SHT .125 STK
.128 DIA THRU TYP 4 PLACES
CLOSURE DOOR SCALE 1/1
5.920 R REF
4.703 R REF
-003
HINGE SCALE 1/1
-004
TORSION SPRING SCALE 4/1
.280 I.D REF
.250 T.O.C 6 FULL COILS

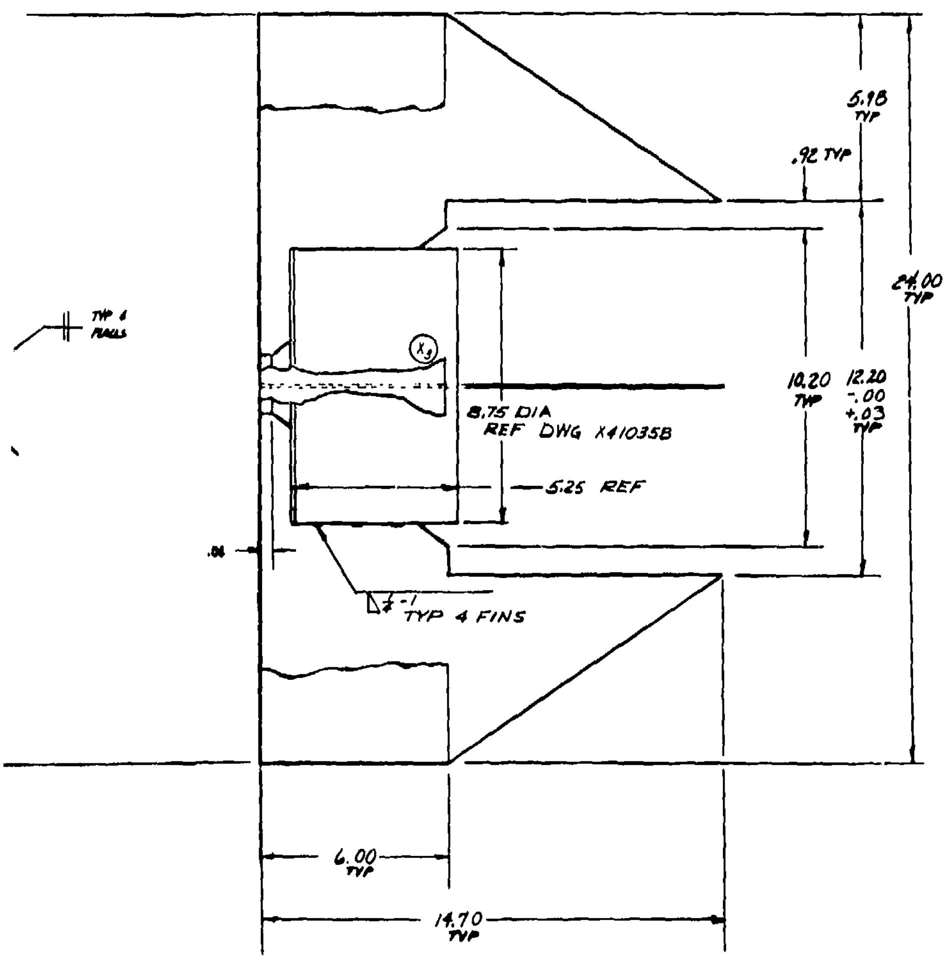

.625±.010 AT BOTTOM OF SLOT
1.375±.010
2.750±.020 DIA
30°±1° TYP
.625 REF
.437±.010
.875 +.020 -.000
2.312±.010 DIA
SLOT X.100±.010 DEEP
60°±1° TYP
FULL RAD BOTH ENDS
1.500 +.020 -.020
1.00±.02
.750±.010
1.500±.010 DIA
THRU TAPERING TO
.625 DIA OTHER SIDE
AS SHOWN
SECTION A-A
KAMAN SCIENCES CORPORATION
INTERPRET THIS DRAWING PER ANSI Y-14
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCE
SURFACE ROUGHNESS
DO NOT SCALE THIS DRAWING
MATERIAL
ALUM
APPLICATION
C
21732


KAMAN SCIENCES CORPORATION
BRACKET, CAPACITOR GAUGE CLOSURE ASSY
C 21732
X410259
ALUM ANGLE
450315
DUMP
APPLICATION
.421 ±.010 DIA THRU 2 HOLES
.281 ±.010 DIA THRU 1 HOLE
2.313 DIA ESC CIRCLE
.406 REF
30° ± 1°
2.00 ±.01
.125 ±.010
STOCK



6
5
4
3
D
C
B
A
TYP 4 PLACES
4 PLACES
.040 STK TYP
2.00 DIA
6.00 TYP
UNLESS OTHERWISE SPECIFIED:

3-B	X2	PRODUCTION ISSUE - REVISED GUSSETS TO 1/2 SCALE		
3-C	X3	PRODUCTION ISSUE - ADDED HOUSING, PARACHUTE STOWAGE		
	X4	REVISED FOR NEW [illegible]		



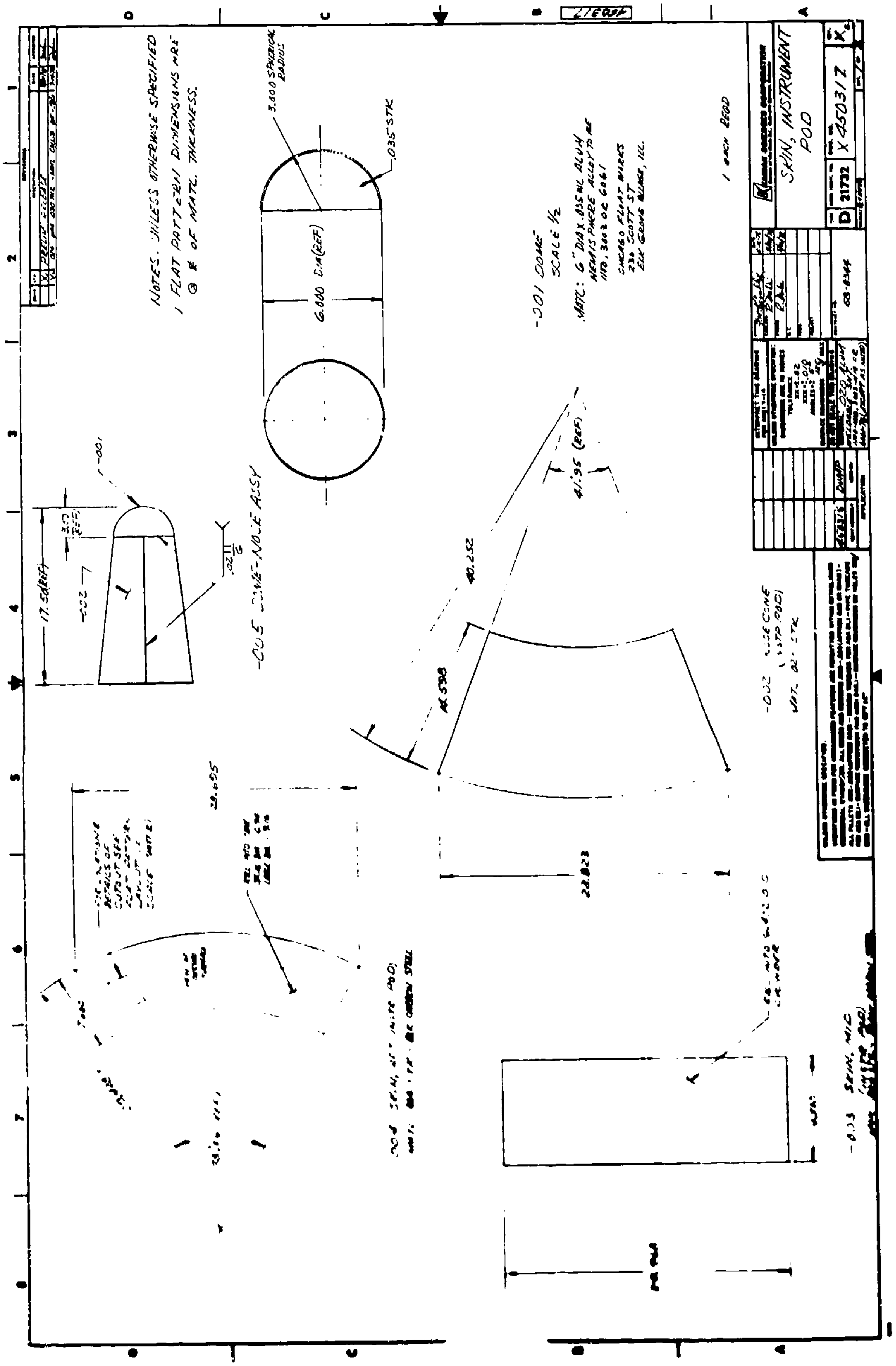
NOTES:

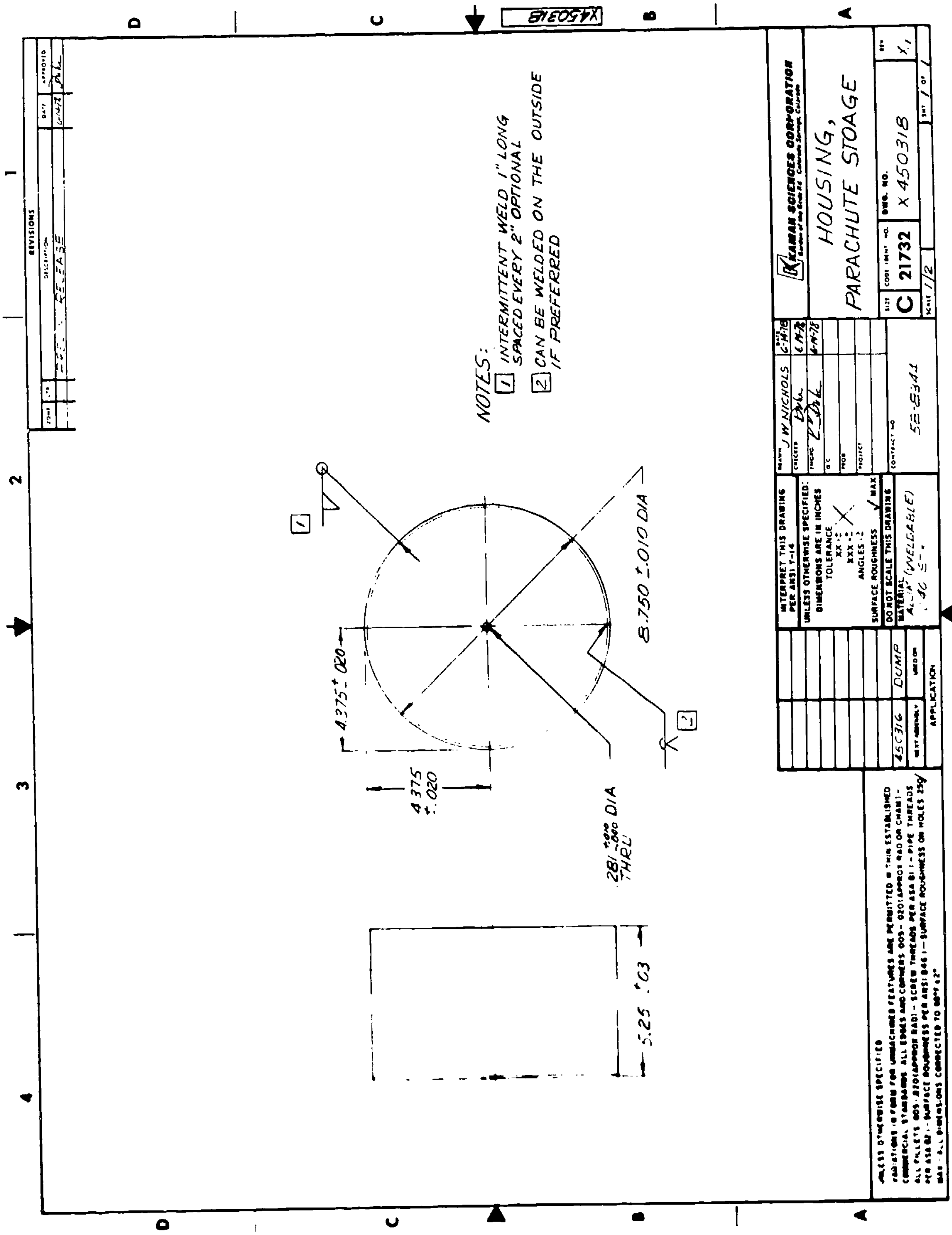
1 MAT'L. : ALUM SHEET .040 THK. 1100-H18, 3003-H18 or 6061-T6

FIN ASSEMBLY, DUST CLOUD

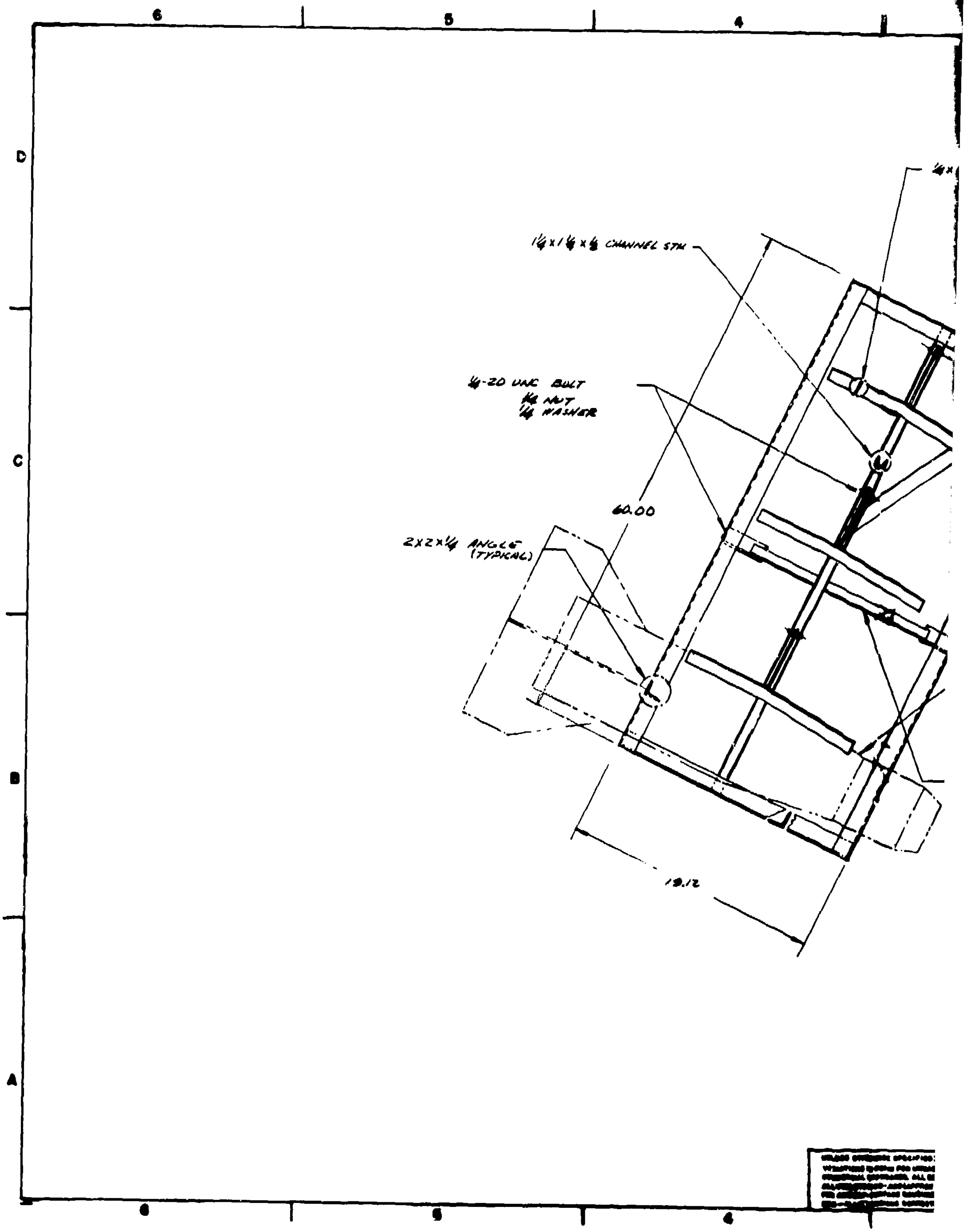
F 21732 450316 X

450316

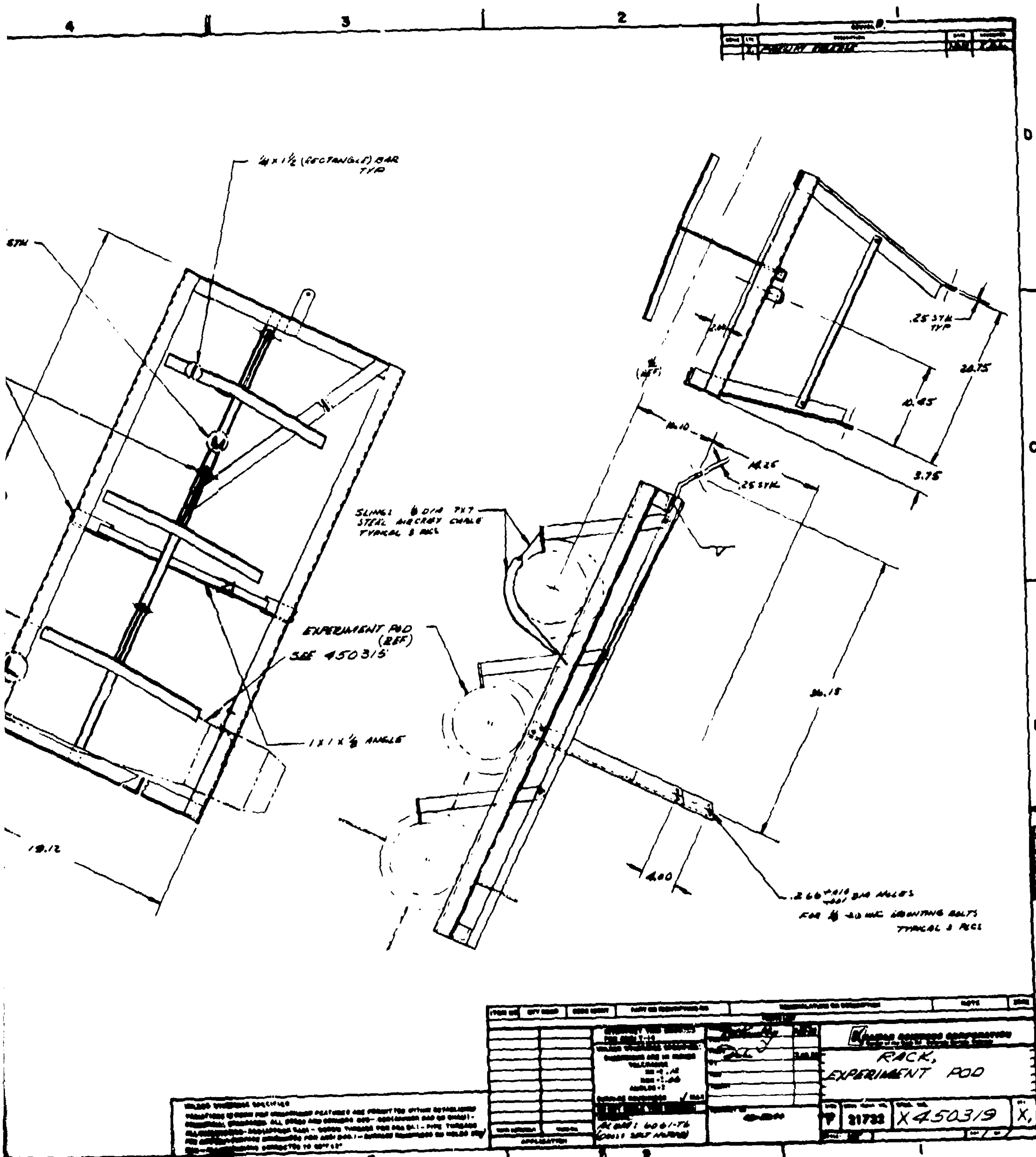

NOTES: UNLESS OTHERWISE SPECIFIED
1. FLAT PATTERN DIMENSIONS ARE @ ℄ OF MATL. THICKNESS.
3.000 SPHERICAL RADIUS
.035 STK
6.000 DIA(REF)
-001 DOME
SCALE 1/2
1 EACH REQD
-005 CONE-NOSE ASSY
17.50(REF)
SKIN, INSTRUMENT POD
21732
X450312



NOTES:
1 INTERMITTENT WELD 1" LONG SPACED EVERY 2" OPTIONAL
2 CAN BE WELDED ON THE OUTSIDE IF PREFERRED
8.750 ±.010 DIA
4.375 ±.020
.281 +.010 -.000 DIA THRU
5.25 ±.03
REVISIONS
RELEASE
KAMAN SCIENCES CORPORATION
HOUSING, PARACHUTE STOAGE
C
21732
X 450318
SCALE 1/2
J W NICHOLS
SE-8341
45C316
DUMP
APPLICATION
INTERPRET THIS DRAWING PER ANSI Y-14
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES
DO NOT SCALE THIS DRAWING
X450318



6
5
4
D
C
B
A
1¼ x 1¼ x ⅛ CHANNEL STK
¼-20 UNC BOLT
¼ NUT
¼ WASHER
60.00
2X2X¼ ANGLE
(TYPICAL)
19.12


1/4 x 1 1/2 (RECTANGLE) BAR TYP
SLINGS 1/8 DIA 7x7 STEEL AIRCRAFT CABLE TYPICAL 3 PLCS
EXPERIMENT POD (REF)
SEE 450315
1 x 1 x 1/8 ANGLE
19.12
4.00
36.15
28.75
10.45
3.75
.25 STK TYP
RACK,
EXPERIMENT POD
21732
X450319

APPENDIX B

Memorandum "Safety of Hiller UH-12E in MISERS BLUFF 1" to Dr. Frank Shelton from Dr. N. Hobbs and G. Zartarian, on June 21, 1978.

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DATE: 21 June 1978

TO: DNA, Mr. James F. Moulton, Jr., SPAS

FROM: Frank H. Shelton, KSC

Please note following message to F. Shelton from AviDyne.

TO: Dr. Frank Shelton

FROM: Dr. N. Hobbs, G. Zartarian

SUBJECT: Safety of Hiller UH-12E in MISERS BLUFF 1

DATE: June 21, 1978

We have addressed the question of the safety of the Hiller UH-12E helicopter hovering over ground zero in MISERS BLUFF 1 at an altitude corresponding to a shock overpressure of 0.2 psi. We have obtained some data on the UH-12E from Mr. Samuel Brodie, Chief Engineer for Hiller Aviation.

Due to time restrictions and limited data available, we have had to employ simple analysis methods and engineering judgment rather than applying more sophisticated methods. We have looked at the rotor system and the plexiglass bubble (for which we have virtually no data), which we should expect to be the two most vulnerable components of the UH-12E. As a result of our brief analyses, it is our opinion that the UH-12E is indeed safe at the specified conditions. We believe that the HU-12E has an adequate margin of safety to cope with uncertainties with regard to the expected shock overpressure and the analysis tools used.

On the basis of our cursory examination, we would not be willing to approve of a higher overpressure level for MISERS BLUFF1. We suspect, however, that a more detailed analysis of

the UH-12E would result in our accepting a higher overpressure as safe, due to increased confidence in the analysis. We suggest that a more detailed analysis be conducted if it turns out to be desireable to clear UH-12E to a higher overpressure level for MISER BLUFF 2.

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